

# APPLIED MECHANICS *Reviews*

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AND RELATED ENGINEERING SCIENCE

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# APPLIED MECHANICS

# Reviews

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# APPLIED MECHANICS REVIEWS

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## MAGNETOHYDRODYNAMICS—A SURVEY OF THE LITERATURE

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### INTRODUCTION

**M**agnetohydrodynamics is concerned with the manner in which magnetic fields interact with electrically conducting fluids. Our understanding of magnetohydrodynamic problems has reached a very advanced stage in the past few years. This is mainly the result of intensive investigations which have been instigated by attempts made to achieve controlled nuclear fusion reactions, by the study of high-speed vehicles, and by recent progress in astrophysics and geophysics.

The continuum point of view has been emphasized in this review. The theory is then applicable to liquids and to dense ionized gases. Specifically, the continuum theory is valid whenever electrical neutrality is preserved in the gas and the mass stress-tensor is isotropic. Whenever these criteria break down, the continuum theory must be replaced by a kinetic theory for the gas. Although several earlier attempts had been made to discuss the behavior of conduction currents in an ionized gas (plasma), no systematic study of the motion of a fluid immersed in a magnetic field was started until Alfvén (1) in 1942 wrote his now classical papers.

In view of the short space allocated to this survey paper, several topics of interest to magnetohydrodynamics have of necessity been omitted. The subject matter of this review has been divided in five parts. In the first part, the governing equations for the motion of the fluid are discussed. The second part treats the dynamical theory of magnetohydrodynamic waves of small amplitudes. In the third part the discussion is devoted to magnetohydrostatic considerations. The general problem of instability is taken up in Part Four. Finally, the last part summarizes our present understanding of magnetohydrodynamic shock theory.

There are several excellent review articles in the literature (2), (3), (4), (5), and (6) which emphasize different aspects of this rapidly growing field. In addition to these articles, a few monographs have also been published (7), (8), (9).

### I. FUNDAMENTAL CONSIDERATIONS

The governing relations for the motion of the conducting fluid are generally derived by means of (i) Maxwell's equations corrected for the relative motion of the fluid; (ii) the equations for the conservation of the mass and momentum; (iii) the constitutive equations for its magnetic and electric properties, also an equation of state defining the dependence of the density on the pressure and the temperature; and finally (iv) the equation for the conservation of energy.

It is apparent from the list indicated above that the equations of magnetohydrodynamics are nonlinear. They actually

carry over this feature which is common to problems of conventional hydrodynamics. As a result, such characteristic phenomena of hydrodynamics as turbulence and shock waves are expected to be encountered. In addition to these, other effects are found which are due to the direct interaction of the motion with the magnetic field. The Alfvén's wave is a typical instance of such phenomena.

In a highly ionized gas or in a fluid with high electrical conductivity, the electrostatic forces are negligible. Indeed, it turns out that in a plasma the ratio of the forces due to the electric field to those produced by the magnetic field is of the order  $(v/c)^2$ , where  $v$  is a characteristic velocity for the fluid and  $c$  the velocity of light. The combined hypothesis of high electrical conductivity and electrical neutrality of the fluid is responsible for the absence of the displacement current from the equations of magnetohydrodynamics. An immediate consequence of this fact is the exclusion of purely electromagnetic radiation phenomena from the discussion. For a Stokesian fluid, the conservation of momentum is expressed by

$$\rho \frac{d\mathbf{v}}{dt} = -\nabla p + \mathbf{J} \times \mathbf{B} + \nu \rho \left( \nabla (\nabla \cdot \mathbf{v}) + \frac{1}{3} \nabla^2 \mathbf{v} \right) \quad [1]$$

Manipulation of the electrical equations, on the other hand, leads to

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{v} \times \mathbf{B}) + \frac{1}{\mu \sigma} \nabla^2 \mathbf{B} \quad [2]$$

The units for the above relation are in MKS. Furthermore,  $\rho$  stands for the mass density,  $\mathbf{v}$  for the fluid velocity,  $p$  is the pressure,  $\nu$  the kinematic viscosity,  $\mu_0$  the magnetic permeability,  $\sigma$  the electrical conductivity,  $\mathbf{J}$  the current density and  $\mathbf{B}$  the magnetic field density.

The mechanical and electromagnetic consequences of the two above equations can be clarified by means of a dimensional analysis. One accordingly introduces two decay times  $\tau_1 = (\sigma B_0^2)^{-1}$  and  $\tau_2 = \mu_0 \sigma L^2$  where  $B_0$  and  $L$  are, respectively, a characteristic magnetic field and a characteristic length. The time  $\tau_1$  is an indication of a relaxation time for the decay of the fluid motion by means of induction drag, while  $\tau_2$  denotes the diffusion time of the magnetic field in the fluid. The use of these times in Eq. [1] leads to the identification of a conventional Reynolds number  $R = VL/\nu$ , to a magnetic Reynolds number  $R_m = VL/\nu_m$  where the magnetic viscosity  $\nu_m = (\mu_0 \sigma)^{-1}$ , and to a Hartmann number

$$M = \left( \frac{\tau_2}{\tau_1} \frac{R}{R_m} \right)^{1/2} = B_0 L \left( \frac{\sigma}{\rho \nu} \right)^{1/2}$$

The importance of  $M$  first appeared in Hartmann's investigations on the flow in channels (10). There, it is of interest to identify the relative effects of the loss mechanisms. It then appears that the effect of magnetic viscosity is dominant if  $M \gg 1$ , otherwise the viscous forces are preponderant in controlling the character of the flow (11), (12). The role of  $R_m$ , on the other hand, is clearly demonstrated when rewriting Ohm's law as

$$\nu_m (\nabla \times \mathbf{B}) = \mathbf{E} + (\mathbf{v} \times \mathbf{B}) \quad [3]$$

The left-hand side of the equation is of the order of  $1/R_m$  compared to the right-hand side. At large  $R_m$  the fluid behaves as though it were an ideal conductor in the sense that the electric field in the fluid is almost balanced by the motion induction, little contribution being provided by the Ohmic voltage drop. The number  $R_m$  is not a measure of the transition between laminar and turbulent flow, but is instead an indication of the stiffness of the fluid to the magnetic field. The demonstration goes this way:  $R_m = \tau_e V/L = \tau_e T^{-1}$ , where  $T$  is a characteristic time for the material motion of the fluid. At large values of  $R_m$ , i.e., for  $\tau_e \gg T$ , the fluid would have suffered extensive deformation before the magnetic field penetrates the fluid. Indeed, in the limiting case of  $R_m \rightarrow \infty$ , the magnetic lines of force are "frozen" in the fluid (13), (14).

## II. MAGNETOHYDRODYNAMIC WAVES

An ideal inviscid incompressible fluid cannot sustain sound waves. These waves, depending on the compressibility of the fluid, are purely longitudinal. Alfvén (1) was able to show that an electrically conducting incompressible fluid permeated by a magnetic field may be the seat of transverse waves which he called magnetohydrodynamic waves. It is known (15) that the magnetic stresses set up in a medium consists of a distributed uniform pressure equal to  $B^2/2\mu_0$  together with a uniform tension directed along the lines of force and equal to  $B^2/\mu_0$ . When one imagines the fluid to be perfectly conducting, then the lines of force appear as though they are frozen in the fluid. Hence any displacement of the lines normal to themselves would entrain the fluid with it. It is then possible to visualize the lines of force as heavy strings of density  $\rho$  and under a tension of  $B^2/\mu_0$ . But from the classical theory of vibrations, the velocity of propagation of a transverse perturbation on a string is equal to the square root of the tension by its density. By analogy, the Alfvén's waves should then

have a velocity  $\left(\frac{B^2}{\rho\mu_0}\right)^{1/2}$ .

A more rigorous proof for the existence of these waves can also be had by using a symmetrical form for Eqs. [1] and [2] due to Elsasser (16) and Lundquist (17). This is seen at once when the transformations  $\mathbf{u} = \mathbf{v} + \frac{\mathbf{B}}{\sqrt{\mu_0\rho}}$  and  $\mathbf{w} = \mathbf{v} - \frac{\mathbf{B}}{\sqrt{\mu_0\rho}}$  are introduced. The two aforementioned equations become

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{w} \cdot \nabla) \mathbf{u} + \nabla \Phi - \alpha \nabla^2 \mathbf{u} - \beta \nabla^2 \mathbf{w} = 0 \quad [4]$$

$$\frac{\partial \mathbf{w}}{\partial t} + (\mathbf{u} \cdot \nabla) \mathbf{w} + \nabla \Phi - \alpha \nabla^2 \mathbf{w} - \beta \nabla^2 \mathbf{u} = 0 \quad [5]$$

where  $2\alpha = (\nu + \mu_0\sigma)$ ,  $2\beta = (\nu - \mu_0\sigma)$  and  $\Phi = p + \frac{B^2}{2\mu_0}$ .

Two sets of simple solutions for these equations can be found, when the incompressible fluid is in a homogeneous magnetic field  $B_0(\mu_0\rho)^{-1/2}$  directed along the  $z$ -axis. One then obtains for the set

$$\mathbf{u} = 0; \quad \frac{\partial u}{\partial t} - B_0(\mu_0\rho)^{-1/2} \frac{\partial u}{\partial z} = 0 \quad [6]$$

and

$$u = 0; \quad \frac{\partial w}{\partial t} - B_0(\mu_0\rho)^{-1/2} \frac{\partial w}{\partial z} = 0 \quad [7]$$

It is assumed that the quantity  $\Phi$  is a constant. This implies that the magnetic pressure is balanced by the pressure of the fluid. Inspection of either one of the above equations leads us at once to identify the velocity of the  $u$  or  $w$  wave as the Alfvén's velocity.

The general treatment of magnetohydrodynamic waves of finite amplitudes is complicated by the nonlinearity of the governing equations. This means that several properties of linear phenomena (superposition theorem, reciprocity theorem, etc.) do not apply to these waves (2). The behavior of small magnetohydrodynamic disturbances in an incompressible fluid with a uniform field, on the other hand, has received a great deal of attention (30), (31). The general character of these waves, taking into account compressible effects, was first discussed by van de Hulst (18), Herlofson (19), and Bänds (20). Special cases, however, had been considered earlier by Walén (21) and by Åström (22) who demonstrated the transition between magnetohydrodynamic waves and electromagnetic waves in an ionized gas.

The linearized theory for these waves indicates that for a lossless compressible fluid there are three modes of propagation. One of these modes corresponds to the Alfvén wave mentioned above which travels with a modified velocity. The mass velocity in this mode is perpendicular to the plane containing the field and the direction of propagation. The two other modes (slow and fast modes) appear as a result of the coupling of the Alfvén mode with the true acoustic mode. The mass velocity for these two modes lies in the plane of the field and direction of propagation. The modified velocity of the Alfvén wave depends on the relative angle between the field and the direction of propagation. When this angle is zero, one finds two pure Alfvén modes and an unaffected sound wave. In the other extreme case when the angle is  $90^\circ$ , two of the modes disappear and the third mode is an acoustic mode with a modified velocity.

Because of its importance to several fields, the subject of the reflection and refraction of magnetohydrodynamic waves has been considered by a number of authors (23), (24), (4). One of the crucial points to the theory of the reflection or refraction of the waves is the specification of the boundary conditions at the interface responsible for the reflection and the refraction. On an interface there can be no surface current if the magnetic field has a non-vanishing component normal to the interface, as this would lead to infinite acceleration. Thus in this case, the magnetic field is continuous. A jump in the tangential component, however, is possible, and hence a surface current, if the normal component is zero. The jump in the normal component of the electric field is equal to the normal velocity of the interface multiplied by the jump of the

magnetic field. Finally, both the total pressure  $\left(p + \frac{B^2}{2\mu_0}\right)$

and the normal component of the velocity are continuous at the interface. When there is a rate of change of the normal  $n$  to the interface as a result of the motion, then it can be shown that (25)

$$\mathbf{n} = -(\nabla \cdot \mathbf{v}) \cdot \mathbf{n} + \mathbf{n} \cdot (\nabla \cdot \mathbf{v}) \cdot \mathbf{n} \quad [8]$$

The complication of the theory of reflection and refraction arises from the fact that a pure mode incident on an interface can be coupled to other modes upon reflection and/or refraction. One can demonstrate (26) that one can have at an interface a single reflected mode (due to a slow or fast mode) and at most a single refracted mode.

The discussion of magnetohydrodynamic waves in guides reduces to a tractable problem when the axis of the wave

guide coincides with the direction of the magnetic field (27), (28), (29) and when the guide is a long tube (circular or rectangular) with rigid infinitely conducting boundaries. For the case of the cylindrical configuration, there are three simple modes when the direction of propagation is parallel to the axis of the guide. One mode for which the mass velocity is along the direction of propagation proceeds as an undisturbed sound wave and has a cut off when its wavelength is greater than the radius of the tube. The third mode behaves as a torsional wave which suffers no cut off. As one considers other directions of propagation, the behavior rapidly becomes quite complicated.

### III. MAGNETOHYDROSTATICS

This section is mainly devoted to static considerations. More specifically, equilibrium configurations for the conducting fluid in the magnetic field are studied. The mathematical formulation for this problem is obtained from Eq. [1] in which terms containing  $v$  are discarded. This leads to the equation of magnetohydrostatics

$$\nabla p = \mathbf{J} \times \mathbf{B} \quad [9]$$

A class of solutions to the above equation corresponds to the situation of vanishing right-hand side. The physical interpretation of this is that the current is everywhere parallel to the magnetic field, so that interaction of the current with the magnetic field gives rise to no force. These force-free fields are of interest to astrophysical investigations (32), (33) as well as to designers of electromagnets for strong fields (34). The behavior of force-free fields may be obtained by studying solutions of the equation

$$(\nabla \times \mathbf{B}) \times \mathbf{B} = 0 \quad [10]$$

Such solutions have been reported in the literature on astrophysics (35). One of the earliest derivations, however, due to Beltrami (36), arose in connection with a problem in fluid dynamics requiring the steady-state motion of a fluid for which the total dynamic pressure remains constant. This, of course, is equivalent to the investigation of the condition satisfying  $(\nabla \times \mathbf{v}) \times \mathbf{v} = 0$ .

The general solution of Eq. [9] is less restrictive than the case of the force-free field. Here, also, one finds several discussions of Eq. [9] in connection with problems in astrophysics (37), (38). These solutions, however, are of special interest because of their importance to the study of plasma confinement. It was pointed out by Kruskal and Kulsrud (39) that whenever  $p$  is constant on the boundary of its region of definition, then under some mild assumptions, that boundary must be topologically a toroid. Another consequence of this result is that the equation  $p = \text{constant}$  defines magnetic surfaces made up of lines of force.

Since several equilibrium configurations are inherently unstable, magnetohydrostatic solutions are of special importance to the study of stability. The manner in which these solutions are used is shown in the following section.

### IV. HYDROMAGNETIC INSTABILITIES

Investigations on the stability of hydromagnetic systems have been of interest to a multitude of fields concerned with such problems as the dynamics of sunspots, interstellar matter, auroras, gas discharges and flows of liquid metals in channels. An excellent survey of some of these applications is given in (5).

Broadly speaking, two kinds of instability problems have been studied in magnetohydrodynamics. The stability of the system is studied about an equilibrium configuration which is either static or dynamic. In the first class of problems the theory of vibration plays an important role in the discussion. In the second kind one encounters instabilities of the sort

considered in conventional hydrodynamics, except that here, as a result of the presence of the magnetic field, something like a viscous drag acts on the conducting fluid and an added rigidity must be introduced in the analysis.

One of the earliest attempts at deriving a criterion for the stability of a system about its static equilibrium configuration was presented by Lundquist (40). The criterion he proposed required that a change of the potential energy of the system about its equilibrium configuration must be positive if the system is stable. A much more general criterion for the stability was derived by Bernstein, Frieman, et al (41). Their energy principle depends upon a variational formulation for the equations of motion of small perturbations about static equilibrium. It was first used by Rayleigh (42) in the calculation of the frequencies of vibrating systems. Its advantage lies in the fact that if one seeks solely to determine stability, and not rates of growth or oscillation frequencies, it is necessary only to find out whether there is a perturbation that will reduce the potential energy from its equilibrium value. This method allows one to investigate the stability of much more complicated equilibria than the normal mode method would allow (43), (44). The Bernstein energy principle was used by him and his collaborators to study the general stability condition of plasmas completely separated from the magnetic field by an interface and the stability of general axisymmetric systems. The energy principle was also extended to other configurations by various investigators (39), (45), (46), (47).

The studies of instability about configurations in dynamic equilibrium have also been treated by perturbation methods. Unfortunately, these methods are not altogether adequate since the flow is sometimes stable for small disturbances but unstable for large. No method superior to the perturbation method, however, has been devised. The instability of liquid flow between parallel walls has been treated by Stuart (48) and Lock (49). Both authors find that the perturbation most likely to induce instability is a two-dimensional one, in which the motion is limited to planes normal to the walls and containing the unperturbed stream lines. The magnetic field is supposed uniform, and also parallel to the walls.

The stability of hydromagnetic systems has also been studied extensively by Chandrasekhar (50) and others (51), (52). Some of the cases considered were: the effect of a magnetic field on the stability of a liquid flow between two coaxial cylinders rotating at different rates; problems of thermal instability; the effect of Coriolis and gravity forces on the stability.

### V. HYDROMAGNETIC SHOCKS

It is well known from classical hydrodynamic shock theory that the state on one side of the shock can be computed from the state on the other side and from the strength of the shock, by a direct use of the laws of conservation of mass, momentum and energy. The particular nature of the dissipative process in the shock determines the structure but leaves the end states unaffected. This explains why it is possible to solve problems in gas dynamics by resorting to ideal nondissipative fluids and then join solutions at selected shock fronts. A similar situation applies to magnetohydrodynamics where the effects of an additional dissipative mechanism—the Ohmic losses—needs to be included in the energy balance.

The conventional hydrodynamic theory leads to the formal recognition of both longitudinal and transverse shocks, when the mass motion is, respectively, parallel to and perpendicular to the shock propagation. In magnetohydrodynamics a parallel situation is encountered in that both longitudinal and transverse shocks may be identified. Here, the transverse shock has a finite non-zero velocity, which in the limit of small amplitude becomes the usual Alfvén wave.

One of the earliest systematic treatments of magnetohydrodynamic shocks in an inviscid, infinitely conducting fluid is

that of de Hoffmann and Teller (53). Their analysis, which includes relativistic effects, was later clarified in some of its phases by Helfer (54).

Any full treatment of shock structure, however, must consider an application of the kinetic theory of non-equilibria, since the width of the shock is of the order of a few mean free paths—a fact known for a long time (55). In the presence of a magnetic field, one would expect that conventional continuum theory will apply provided that the times entering the discussion are small compared to the cyclotron period and that the field values do not vary appreciably over a distance comparable to a Larmor radius. This clearly indicates that the continuum theory is valid mainly for weak shocks.

Progress, however, has been achieved by classical theory which yields, at best, prediction with reliable orders of magni-

tude. The discussion of shock structure by the continuum theory must include the dissipation of energy by viscosity and heat conduction in the calculations (56). This enables the field quantities to vary continuously in the finite width of the shock front (57). For high conductivity, the shock front has a width of several mean free paths. For low conductivity, if the initial magnetic field is smaller than a certain critical value, a sharp shock is preceded by a wide region in which the field, velocity and temperature change slowly. If the field is larger than this critical value, then no sharp shock occurs and all the variables change slowly over a wide region. It is also shown (58) that the presence of the magnetic field tends to make the shock front narrower for shocks of moderate strength, and seems to have no appreciable effects on the strong shocks.

In view of the complicated theory of shock waves, progress so far has been restricted only to plane waves.

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# Analytical Methods in Applied Mechanics

(See also Revs. 3205, 3211, 3212, 3213, 3216, 3217, 3223, 3280, 3309, 3318, 3369, 3487, 3572, 3573, 3575)

**3193. Head, J. W., and Oulton, G. M., The solution of ill-conditioned linear simultaneous equations, *Aircr. Engng.* 30, 356, 309-312, Oct. 1958.**

Authors consider system  $Ax = d$  with  $A$  symmetric, showing by a simple example that presence of a small eigenvalue  $\lambda$  leads to ill-conditioning. If  $u$  is normalized eigenvector belonging to  $\lambda$ , they define the scalar

$$U = u^T x = d^T x / \lambda$$

and show that if  $U$  is regarded as known and the equation

$$u^T x = U$$

replaces one of the original equations, the resulting system is often less ill-conditioned. Hence they propose that  $U$  be directly measured if possible to permit the replacement. This suggestion is the only novel feature of paper.

Case of two small eigenvalues is also considered, and two methods are described briefly for finding these and associated vectors: first, escalator method; second, method of false position.

A. S. Householder, USA

**3194. Reggini, H. C., Solution of system of linear equations (in Spanish), *Cienc. y Tec.* 125, 628, 158-167, May 1958.**

Gauss modernized method of solving a system of  $n$  linear algebraic equations in  $n$  unknowns is described. Its process is detailed and its basis is outlined; checking devices during the computation are also explained.

Although the use of linear system in elasticity and structural design is only mentioned, its remarkable importance is obvious in many other disciplines (electricity, hydraulics, economy, etc.) as well as its usefulness in solving linear differential equations on replacing them by finite difference equations. Some analogies will be evident between the explained method and the simplex method which solves linear programming problems.

From author's summary

**3195. Wasow, W., Discrete approximations to the Laplace transformation (in English), *ZAMP* 8, 5, 401-417, Sept. 1957.**

Author discusses the properties and applications of the so-called  $z$ -transformation, which is the discrete analog to the Laplace transformation. Two modifications of the  $z$ -transformation, which are suitable to improve the approximation of the Laplace transformation, are also treated. The analysis of the application of the  $z$ -transformation for the numerical solution of linear and certain nonlinear differential equations gives information on the accuracy of this method and discloses connections with other difference schemes.

F. Engelmann, Germany

**3196. Schroder, J., Perturbation calculation of eigenvalue and branching problems (in German), *Arch. Rational Mech. Analysis* 1, 5, 436-468, Aug. 1958.**

Author treats the problem of the following quite general form:

$$A_0 \phi - \lambda \phi = B(\lambda, \phi), \quad l\phi = 1$$

where the number  $\lambda$  and the corresponding function  $\phi$  are to be determined,  $A_0$  is a linear operator,  $l$  is a linear functional, and  $B(\lambda, \phi)$  is either linear or nonlinear in  $\phi$  (eigenvalue or branching problem). As in the perturbation method, the solution starts with that to a "neighboring" eigenvalue problem of the form  $A_0 \phi - \lambda \phi = 0$ ,  $l\phi = 1$ . However, instead of expressing  $\lambda$  and  $\phi$  in power series of a perturbation parameter, an iteration procedure is then used, which is convenient for numerical work. By rewriting the problem

as

$$Gu = 0$$

where

$$u = \begin{pmatrix} \lambda \\ \phi \end{pmatrix} \quad \text{with} \quad l\phi = 1$$

and

$$G = G_0 + G_1, \quad G_0 u = A_0 \phi - \lambda \phi, \quad G_1 u = -B(\lambda, \phi)$$

the iteration has the form

$$G_0 u_n + G'_0(x_n)(u_{n+1} - u_n) + G_1 u_n = 0 \quad (n = 0, 1, 2, \dots)$$

which was discussed previously by the author [*Arch. Rat. Mech. Analysis* 1, 154-180, 1957], and in which  $G'_0(x_n)$  is related to  $G_0$ .

Since only  $G_0$  is expanded in Taylor's form but not  $G_1$ , this is different from the usual iteration in Newton's method.

The convergence of the procedure and estimate of error are also discussed. The general procedure is next specialized for eigenvalue problems involving matrix equations and second-order ordinary differential equations. Two numerical examples involving matrix equations are then given. Finally, a nonlinear problem of column buckling is discussed as an example of branching problems.

Y.-Y. Yu, USA

**Book—3197. Dixon, W. J., and Massey, F. J., Jr., Introduction to statistical analysis, 2nd ed., New York, McGraw-Hill Book Co., Inc., 1957, xiii + 488 pp. \$6.**

This is the second edition of an elementary textbook designed for a basic course in statistics. The only prerequisite mathematical background is a minimum knowledge of algebraic processes. However, authors recommend that the final chapter on probability be undertaken late in any course based on this volume unless prospective students have the equivalent of two years of high-school algebra. Coverage of statistical topics is very broad for an introductory book and many areas of application are indicated through examples from many diverse fields.

The second edition differs from the first in several areas. The chapters on measures of central value and dispersion, and statistical inference have been largely rewritten. The coverage of analysis of variance has been completely reworked and new material has been included. A new chapter on probability has been added. Other chapters have been revised and new tabular information has been added.

Reviewer believes the authors are to be commended for many excellent facets of this work. In the introduction an excellent discussion is presented on the nature of statistical inference. This topic is again emphasized in an early chapter. The concepts of unbiasedness and efficiency are outlined very clearly. The presentation of analysis of variance is unusually good, and the beginning student will be amply rewarded by a careful study of this material. Perhaps a valid criticism could be made of the banishment of probability to a last chapter. Nevertheless, as the authors point out, a teacher may use his own discretion concerning the timing for introducing this subject.

R. B. Grant, USA

**3198. Langbein, W. B., Queuing theory and water storage, *Proc. Amer. Soc. Civ. Engrs.* 84, HY 5 (J. Hydr. Div.), Pap. 1811, 24 pp., Oct. 1958.**

The application of the "queue-theory" approach to problems of water storage in hydroelectric, flood control, and irrigation systems leads to a general method of calculation called "probability routing." Paper might more appropriately have been titled "A queue analogue to water storage," for the development does not follow the usual developments. An understanding of queue behavior is essential background for this reasonable and practical approach to water planning. The queue analogy is expressed in

the following terms: (a) queue arrival rate = inflow; (b) service function = discharge; (c) queue discipline = order of drawing discharge (selecting drafts may be made from high or low levels to draw off warm or cold water, turbid or clear water, or water differing in salinity); and (d) attrition rate or evaporation rate. Analytic and computing methods are discussed and several complete examples are used as illustrations.

The probability routing method is a sort of single-step queue equation solved by the method of finite differences. The data required are the probability distribution of inflow and the discharge function (which is generally a function of the storage). One of the examples is based on a 54-year record of inflows which allows a reasonably reliable distribution function for annual flows. The probability routing method does not suffer from a number of inadequacies of previously used methods (for example, it has been shown that the storage needed, as calculated by "trial routing," increases with the 0.72 power of the length of the historical record).

Paper should be of great value in the future, and represents a new development in queue theory.

E. Koenigsberg, USA

**3199. Gruzewski, A., Application of a certain stochastic process to the computation of the mean geostatic pressure** (in English), *Arch. Mech. Stos.* **10**, 1, 115-125, 1958.

The mean pressure at a certain depth below the surface of the earth is estimated on the basis of the assumption that the thicknesses of the overlying formations of different specific weights are unknown and can be considered as random variables. The conclusions reached are trivial.

A. M. Freudenthal, USA

## Computing Methods and Computers

(See Revs. 3195, 3211, 3347, 3466, 3558)

## Analogies

(See also Revs. 3615, 3675, 3676, 3678, 3679)

**3200. Ryder, F. L., Energy versus compatibility analogs in electrical simulators of structures**, *J. Aero/Space Sci.* **26**, 2, 108-116, Feb. 1959.

A comparison is made of two different analogs which may be used in solving bar, beam and simplified (approximate) sheet types of structures subjected to static and certain dynamic loadings; namely,

(1) force and moment equilibrium is analogous to current equilibrium and structural deformation compatibility is simulated by voltage compatibility;

(2) force and moment equilibrium is analogous to current equilibrium and the elastic strain energy of the structure is analogous to the resistive power loss in the circuit.

Simple applications of (2) are presented and author claims certain advantages for this method over (1), including (a) simpler circuits, (b) fewer components, (c) more possibilities for compensating for electrical imperfections.

S. F. Borg, USA

**3201. Platt, A., and Norbury, J. F., Temperature inequalities in the electrolytic tank**, *J. Roy. Aero. Soc.* **62**, 570, p. 456 (Tech. Note), June 1958.

**3202. Torgeson, W. L., Kitchar, A. F., and Hill, B. F., Study of the application of an electrolytic tank to 3-dimensional-asymmetrical bodies (as applicable to aircraft icing)**, WADC TR 55-354 (PB 111792), 22 pp. + 20 figs., Mar. 1958.

Report describes the feasibility of an electrolytic tank in combination with an analog computer for the computation of water droplet trajectories about asymmetric aircraft components in incompressible flow. Three-dimensional compressible flow can be treated only in the case of rotationally symmetric flow.

The development of the electrolytic tank and the voltage gradient measuring probe are dealt with. Moreover the measurement errors introduced by the probe are calculated. From a single example of the flow about a sphere it is concluded that the test set-up is adequate for investigation of water droplet impingement characteristics of a wide variety of aircraft components.

J. H. Greidanus, Holland

**3203. Brunner, W., Simulation of a reciprocating compressor on an electronic analog computer**, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-146, 24 pp.

**3204. Voronov, A. A., Pervozvanskii, A. A., and Semenov, V. V., Electrodynamics models of hydraulic turbines and their speed regulators** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 30-46, Jan. 1956.

## Kinematics, Rigid Dynamics and Oscillations

(See Revs. 3224, 3416, 3420)

## Instrumentation and Automatic Control

(See also Revs. 3472, 3517, 3583)

**3205. Zemanian, A. H., On transfer functions and transients**, *Quart. Appl. Math.* **16**, 3, 273-294, Oct. 1958.

Paper treats algebraic system functions belonging to an extended concept of positive real function: the extension consisting in allowing the degree of the denominator to exceed that of the numerator by any amount.

First part of paper gives the characterizing definitions and theorems and gives a classification into classes and subclasses (according to the difference of degree between denominator and numerator and the behavior of the function on the real or imaginary axis). The basic properties of such classes are also deduced.

Second part of paper is devoted to impulse and step responses corresponding to considered system functions with particular regard to bounds of significant response parameters: magnitude, rise and settling times.

Paper closes with some numerical examples.

G. Evangelisti, Italy

**3206. Sarachik, P. E., Cross-coupled multi-dimensional feedback control systems**, AFOSR TN 58-556 (Columbia Univ., Dept. Electrical Engineering, TR T-30/B, CU-46-58-AF-677; ASTIA AD 158 374), 119 pp., May 1958.

Multi-dimensional control systems are that class of control systems whose primary objective is to establish and control precisely a specified functional relation between several variables. It is important to note that the basic performance requirement of such systems is that the desired functional relation be maintained within some limits of acceptable error. Time does not appear explicitly in this requirement, and is used only as a parameter.

This research is concerned with a study of cross-coupled multi-dimensional control systems, that is to say, with multi-dimensional systems having the particular structure in which the desired functional relation is specified parametrically in terms of one of the

variables, and in which the functional errors are used to control all the variables.

The major aspects of the system considered in this work are:  
*Mathematical Description:* The differential equations describing the system are derived and represented rather simply in vector matrix notation.

*Stability:* The proper performance requirements of the overall system are identified with the stability properties of a "reduced system." Three stability theorems are then proven, two of which are applicable to two-dimensional systems and one to the  $n$ -dimensional case.

*Dynamic Behavior and Synthesis:* The linearized equations in the vicinity of equilibrium are derived, and a synthesis procedure is suggested which combines the nonlinear methods required to establish stability in the large with linear designs for good dynamic behavior.

From author's summary

**3207. Naumov, B. N.,** An approximate method for the construction of transitional processes in nonlinear automatic control systems (in Russian), Sb. Rabot po Avtomatike i Telemekhanike, Moscow, Akad. Nauk SSSR, 1956, 52-68; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8655.

An approximate method of numerical-graphical construction of the transitional process in nonlinear systems containing one nonlinear element is presented. The construction is based on the involution integral which is replaced by an approximate expression derived from the rectangular or trapezoidal rule. The form of the transitional process in the separately considered, linear part of the system is assumed known. Two examples are examined of systems described by second-order, nonlinear equations.

E. P. Popov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3208. Freeman, E. A.,** The stabilization of remote position control systems by proportional Coulomb damping, *J. Elec. Control* 3, 3, 310-329, Sept. 1957.

**3209. Dashevsky, L. N.,** Some singularities in the behaviour of dynamic systems near the limits of the steady region (in Russian), Sb. Trudi In-ta Elektrotekhn. Akad. Nauk USSR no. 13, 35-41, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6313.

**3210. Neimark, Yu. I.,** The stability link of open and closed dynamic systems (in Russian), Trudi 3-go Vses. matem. s'ezda. Vol. 1, Moscow, Akad. Nauk SSSR, 1956, p. 63; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 3912.

**Book—3211. Jury, E. I.,** Sampled-data control systems, New York, John Wiley & Sons, Inc., 1958, xv + 453 pp. \$16.

This book contains a comprehensive treatment of the analysis and synthesis of sampled-data control systems, and is particularly timely due to the attention being presently directed toward the incorporation of digital computers into control systems. Author uses frequent examples; there are good problems available; and presentation contains sufficient mathematical treatment to obtain fundamental knowledge of this subject. The only noteworthy omission is the treatment of random signal inputs to sampled-data control systems.

In Chapter 1 the theory of sampled-data control systems is presented in sufficient detail for the reader to obtain the information needed to analyze such a system. This treatment of the fundamentals includes the mathematical description of the sampler, sampled-data system transfer function, the inversion formula, and stability. The modified  $z$ -transform presented in Chapter 2 is an extension of the regular  $z$ -transform to obtain system response at all times as contrasted with only the sampling instants. Chapter 8

treats the use of  $z$ -transform in approximation of continuous systems and in solving difference equations.

In Chapter 3 and 4 a very complete treatment of the well-known analysis methods of continuous systems, the root locus and the frequency response, is presented for the sampled-data system. The synthesis of sampled-data systems by the discrete compensation method and the continuous compensation method is very thoroughly treated in Chapters 5, 6, and 7. These chapters contain sufficient examples and explanation to present very clearly the methods of design. The limitations of  $z$ -transform and analysis for finite pulse width are presented in Chapter 9.

Reviewer feels this book should be in library of every sampled-data control engineer. Book is useful not only as a reference for the practicing engineer but also as a graduate textbook. There are many contributions in the field of sampled-data control written up here for the first time in book form.

V. B. Haas, Jr., USA

**3212. Bertram, J. E.,** The effects of quantization in feedback systems, AFOSR TN 58-323 (Columbia Univ., Dept. Electrical Engineering, TR T-28/B, CU-44-58-677-EE; ASTIA AD 154 227), 88 pp., Mar. 1958.

The present work utilizes the concept of the state of a dynamic system in order to obtain a mathematical formulation which permits an easy determination of the upper bound on the error in the state variables due to quantizers in an otherwise linear sampled-data feedback system. The same formulation in conjunction with the norm of a vector has been used to obtain sufficient conditions for global stability of several classes of nonlinear sampled systems, as well as desirable operating conditions for a random quantizer.

From author's summary

**3213. Rayevsky, S. Ya.,** Some statistical methods in application to the theory of controlled systems (in Russian), Avtoref. Diss. Kand. Fiz.-matem. Nauk, Moscow State University, Moscow, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8667.

**3214. Haeussermann, W.,** Spatial attitude control of a spinning rocket cluster, *ARS J.* 29, 1, 56-58 (Tech. Note), Jan. 1959.

Attitude control possibilities and characteristics of a body with high angular momentum about one axis, the roll axis, are discussed. The investigation has been carried out in view of the attitude control requirements for the spinning top of the Jupiter C, carrying Explorer I.

From author's summary

**3215. Brown, B. P.,** Ground simulator studies of the effects of valve friction, stick friction, flexibility, and backlash on power control system quality, *NACA Rep.* 1348, 13 pp., 1958.

See AMR 10 (1957), Rev. 3028.

**3216. Chien, K. L., Ergin, E. I., Ling, C., and Lee, A.,** Dynamic analysis of a boiler, ASME Conf., Newark, Del., Apr. 1958. Pap. 58-IRD-4, 10 pp.

Authors have undertaken a first study of the response of a steam boiler to changes in various input variables. They start by setting up a mathematical description of the processes—heat transfer, circulatory, and so on—which take place in steam generation. This description is then linearized for small disturbances. The resulting equations have been solved by the use of a differential analyzer.

Results are presented graphically for certain types of disturbances. It is pointed out that the dependence of drum pressure on feedwater flow, steam flow and fuel flow can be approximated by a single time constant, but the relation of this time constant to the boiler characteristics is not discussed. Amplification and more detailed discussion is greatly to be desired, so that this method may be reduced to an engineering tool.

M. A. Mayers, USA

3217. Chien, K. L., Ergin, E. I., Ling, C., and Lee, A., The noninteracting controller for a steam-generating system, *Control Engng.* 5, 10, 95-101, Oct. 1958.

Authors repeat a portion of their analysis described in preceding review, and expand the result to describe the conceptual design of a "noninteracting" controller for a steam generator. This controller will, for example, provide inputs to the boiler fuel controller arising not only from steam pressure and steam, as is now customary, but also (in the case chosen) from drum level. In the same way, the input to the feedwater controller will include the same three variables. By proper choice of constants, the excursions, as shown in analog computations, of both drum level and steam pressure could be markedly reduced from those of a single action controller.

This paper gives the values of the two dominant time constants for the particular boiler under study. It does not, however, show the relation of the values of these time constants to the boiler characteristics.

M. A. Mayers, USA

3218. Sinitsyn, B. S., Analysis of the static errors of systems of auto-control (in Russian), *Nauch. Zap. L'vovsk. Politekh. In-ta* no. 36, 113-124, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11278.

The problem is examined regarding the determination of the static error in an  $n$ -link successive system of auto-control, when the errors are known for the link components and their sensitivity is also known. The same problem is examined to cover the cases of multi-link differential and compensation systems.

E. N. Miroslavlev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3219. Lane, A. W., Klomes, M. S., and Zeigler, E. L., Achieving extremely accurate nonfloated gyros, *Aero/Space Engng.* 18, 1, 43-46, Jan. 1959.

Discussion of a principle which will reduce the incidence of a major failure in ball-bearing suspended gyros.

From authors' summary

## Elasticity

(See also Revs. 3251, 3263, 3267, 3276, 3286, 3288, 3303, 3305, 3315, 3320, 3369, 3397, 3398)

Book—3220. Chillon, P., Resistance of materials [Résistance des Matériaux] Vol. I, Paris, Dunod, 1957, viii + 317 pp. (Paper-bound).

Book is a short first volume of a proposed two-volume set. It contains material usually found in a sophomore course in Strength of Materials. A somewhat novel feature for a beginner's text is a chapter on the theory of elasticity. The equations of compatibility, however, are given only for two-dimensional rectangular co-ordinates. The Airy stress function is introduced. Also in this chapter are presented the equations for the specification of a three-dimensional state of stress at a point. Oddly enough this material is introduced only for the purpose of examining incipient yielding and is not formally related to the rest of the development. The last chapter is on indeterminate structures. Finally, there is appended a set of exercises corresponding to the various chapters.

W. H. Hoppmann, II, USA

3221. Arzhanykh, I. S., Delayed potentials of the dynamics of an elastic body (in Russian), *Trudi In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 16, 5-22, 1955; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11929.

This is a detailed exposition of the author's well-known results regarding the analysis and investigation of the basic dynamic po-

tentials of the isotropic theory of elasticity. For Lamé's dynamic operator a presentation formula is derived, analogous to that of Kirchhoff with delayed potentials for the wave operation. The properties of the potentials introduced thereby are investigated in detail—spatial, surface forces and surface deformations; they are basically analogous to the known properties of the potentials for the three-dimensional, plain layer and double layer. The general boundary problem of the dynamics of an elastic body leads to the linear integro-differential equations, which in particular cases are transformed into the known integral equations, dealing with the problems of Dirichlet, Neuman, of statics and the stationary vibrations of an elastic body.

V. D. Kupradze

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3222. Tsai, A. G., A class of rigorous solutions for the equations of equilibrium of an elastic body, in cylindrical functions (in Russian), *Trudi In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 18, 143-162, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9259.

The equations of equilibrium of a homogeneous, isotropic, elastic body are integrated in cylindrical coordinates. It is demonstrated that in the absence of mass forces the equations permit of separation of the variables by substitution in two groups of the type

$$u_r = f(z) \cos(n\varphi + a) R_r(r)$$

$$u_\varphi = g(z) \sin(n\varphi + a) R_\varphi(r)$$

$$u_z = b(z) \cos(n\varphi + a) R_z(r);$$

for the first group of substitutions

$$f = g = b = e^{kz},$$

for the second group of substitutions

$$f = g = \cos(kz + b), \quad b = \sin(kz + b)$$

The equations are integrated, determining the functions  $R_r$ ,  $R_\varphi$ ,  $R_z$  (these are expressed by linear combinations of the cylindrical functions and their first derivatives). Proof is given that all the fundamental solutions have been found. As a result, 12 linearly independent, rigorous solutions are obtained for the static problems of the theory of elasticity, in cylindrical coordinates.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3223. Skvortsov, V. S., The solution of a system of differential equations of the theory of elasticity by means of finite differences (in Russian), *Nauch. Zap. Lvovsk. Torgovo-ekon. In-ta* no. 2, 199-207, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9262.

On the basis of the researches of Courant, Friedrichs and Levy [*Uspekhi Matem. Nauk* no. 8, 1941], the problem is examined of the existence and singularity of the solution for a system of equations of difference, corresponding to the differential equations of the theory of elasticity for the three-dimensional case in the presence of determinate displacements at the boundary.

P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3224. Arzhanykh, I. S., and Bondarenko, B. A., The representation of the generalized solutions of the statics of the theory of elasticity by determinate integrals (in Russian), *Trudi In-ta Mat. i Mekh., Akad. Nauk UzSSR* no. 16, 34-38, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9256.

The harmonic functions in the expressions for the generalized solutions of the equations of the theory of elasticity, in the form developed by P. F. Pankovich supplemented by the additive term

$\text{rot } \vec{r} \times \vec{H}$ , are represented in integral form according to Whittaker

$$G_x = \int_{-\pi}^{\pi} g_x (x \cos \varphi + y \sin \varphi + iz, \varphi) d\varphi, \text{ etc.}$$

Expressions are given for the displacements and stresses by introducing six arbitrary functions.

A. I. Lur'e

Courtesy *Referativnyi Zhurnal, USSR*

Translation, courtesy Ministry of Supply, England

**3225. Adams, E., A rotating circular cylindrical disk with the thickness profile  $h(r) = 1/(a^2 + b)$  under arbitrary plane edge stresses** (in German), *Z. Flugwiss.* **5**, 11, 331-334, Nov. 1957.

The outer edge of a rotating circular cylindrical disk with the thickness profile  $h(r) = 1/(a^2 + b)$  is under a load of arbitrary plane edge stresses. The first part of paper deals with plane stresses inside the disk caused by the axisymmetric basic part of the edge load, calculated by means of power series. In the second part, the influence functions inside the disk of the non-axisymmetric part of the edge loads are calculated by means of power series.

From author's summary

**3226. Necas, J., Solution of the biharmonic problem for an infinite wedge** (in Czech) *Casopis Pest. Mat. Fys.* **83**, 257-286 and 399-424, 1958.

Author proves the existence and uniqueness of the solution of the biharmonic problem (plane problem of the theory of elasticity) for an infinite wedge. Biharmonic problem for a plane polygon is also solved. Mellin's transform is used and discussed in detail. Practical calculation is performed by introducing the four Green functions obtained through the formal use of the convolution theorem. Difficulties involved in the numerical calculation are completely studied.

P. P. Teodorescu, Roumania

**3227. Szelagowski, F., Solution of the plane problem of elasticity in a system of Cartesian coordinates, mass forces being taken into consideration** (in English), *Arch. Mech. Stos.* **10**, 1, 99-106, 1958.

Paper deals with the solution of the plane problem of elasticity in Cartesian coordinates, taking mass forces into account. The general solution will be the sum of the general solution of the homogeneous equations, where  $X, Y = 0$ , and a particular solution of the nonhomogeneous equations. The first one has already been treated in other papers; to find the second, author introduces complex variable and expresses the three basic equations in terms of two. Integrating both equations and adding the results to the corresponding equations concerning the general solution, author obtains formulas expressing the general solution of the complete equations, in which  $\phi(z)$  and  $F(z)$  appear as independent analytic functions, related to the boundary conditions. Furthermore, author discusses the form which  $X$  and  $Y$  may assume, concluding that both may only be assumed as an integral of homogeneous differential equations. Cases are also analysed where  $X, Y$  derive from a potential, and corresponding expressions of force and displacement components are deduced in terms of functions of complex variable.

E. D. Fliess, Argentina

**3228. Kammerer, A., A more complete solution of the problem of a concentrated force applied at the edge of a two-dimensional semi-infinite mass** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 31-39.

Paper draws attention to the apparent paradox of infinite displacements according to Boussinesq's solution of the two-dimensional problem of a semi-infinite elastic solid under a concentrated load. It is mentioned that results of photoelastic investigations contradict furthermore the theoretical prediction of zero normal stress along the free surface perpendicular to the line of load application. It is asserted that Boussinesq's solution is incomplete

for the two-dimensional as well as for the three-dimensional case. A solution in terms of infinite series is given for the two-dimensional problem of a semi-cylinder with a concentrated load along its center line and rigidly supported over the semi-cylindrical part of its surface. The solution for the semi-infinite solid should, according to author, follow by letting the radius of this semi-cylinder tend to infinity. However, author does not prove convergence of the series that are thus obtained, and according to reviewer these series do not converge.

J. F. Besseling, USA

**3229. Paduart, A., Solution of a two-dimensional problem of elasticity by means of a method of assimilation** (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 5-15.

Paper presents an application of six nomograms, which permit a determination by the method given by Massonet [AMR **3** (1950), Rev. 231] of the corrections that have to be applied to the results of the simple beam theory in the case of a beam of finite length with rectangular cross-section for an arbitrary load distribution along the boundaries. It is mentioned that the nomograms are based on a complete solution by means of the Airy stress function of the problem of a beam of infinite length under concentrated loads. No references are given.

J. F. Besseling, USA

**3230. Sanders, J. L., Jr., Effect of a stringer on the stress concentration due to a crack in a thin sheet**, NACA TN 4207, 14 pp. + 1 table + 5 figs., Mar. 1958.

Author treats a problem of timely and vital importance. Coefficient is found for determining the influence of a reinforcing stringer on the stress concentration factor at the tip of a crack in a thin sheet under tension. Results are given when the stringer is intact and when stringer is broken. In the first case, the stress concentration for the stringer is also given. Problem is simplified by assuming the sheet to be inextensible in the direction of the crack and the crack a straight slit of small radius at the ends. The strength of the singularity at the ends is taken to be a measure of the stress concentration.

The stress concentration factor for a crack in a thin sheet is taken from a known formula. The number by which this factor should be multiplied in the presence and absence of a stringer is the object of the paper.

The formulation of the boundary-value problem and subsequent discussion leads to formulas for the necessary coefficients, followed by an example in which the stress-concentration factor is found to be quite large. Author states that the effect of plasticity will considerably reduce this factor but does not substantiate this statement except to refer to another paper. Author is to be complimented for his direct approach to the problem.

S. Sergev, USA

**3231. Solomon, L., and Draghicescu, D., On the use of conformal mappings in the plane problem of elasticity for double-connected regions** (in Russian), *Acad. Repub. Pop. Romine, Rev. Mécan. Appl.* **3**, 2, 95-111, 1958.

Paper gives a solution for the plane problem of the theory of elasticity in the case of a doubly-connected region. This solution is based on an alternating method resembling Schwartz's generalized method. In this way, Muskhelishvili's functions can be constructed by successive approximations. Results are applied to a domain situated between two concentric squares with parallel sides.

P. P. Teodorescu, Roumania

**3232. Tamate, O., Influence of a circular hole on the deflection of a thin half-plane** (in German), *Ing.-Arch.* **26**, 3, 181-186, 1958.

A large plate, having a hole of radius  $r$  at a distance  $d$  from its one free edge, is subjected to bending and torsional moments and shear forces at its other edges, which are far from the hole. After showing how this problem can be attacked by conformal mapping

methods, author solves the particular case of pure bending parallel to the free edge. The solution is in the form of a series which is found to converge with sufficient accuracy in seven terms for most practical problems. Stress concentration factors are shown as functions of Poisson's ratio and  $r/d$ .

The reader is cautioned that in author's notation,  $M_x$  means moment about a y-axis.

A. D. Topping, USA

**3233. Gubkin, S. I., and Micevich, N. I., The distribution of the normal stresses on the contact surface in the free swaging of metals** (in Russian), *Sb. Nauch. Tr. Fiz.-Tekhn. In-ta Akad. Nauk BSSR*, no. 2, 37-53, 1955; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3506.

**3234. Chankvetadze, G. G., Elastic semispace with spherical cavity** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22**, 65-73, 1955.

**3235. Ignaczak, J., Thermal displacements in an elastic semispace due to sudden heating of the boundary plane** (in English), *Arch. Mech. Stos.* **9**, 4, 395-416, 1957.

The title problem is discussed within the framework of the uncoupled equations of thermoelasticity, i.e., on the assumption that the temperature field is governed by the diffusion equation. The solution is obtained explicitly for the case of sudden heating at a point on the bounding plane.

H. Deresiewicz, USA

**3236. Forray, M. J., Thermal stresses in plates**, *J. Aero/Space Sci.* **25**, 11, 716-717 (Readers' Forum), Nov. 1958.

Author reviews static plane stress equations with temperature varying in plane but material coefficients constant. Stresses can be found from Airy stress function  $\phi$  which is a solution of the compatibility equation

$$\nabla^4 \phi = -E \alpha \nabla^2 T.$$

The general solution to this is well known. Let the polar coordinates in the plane of the plate be  $r$  and  $\theta$ . A particular solution for  $\phi$  is found for the case that  $T$  (temperature) can be expressed as a Fourier series in  $\theta$  with coefficients a function of  $r$  only.

The solution is applied to a circular plate of radius " $a$ " with the particular temperature distribution

$$T = T_1 + T_0 (r/a)^2 (1 - \cos \theta).$$

Both  $\phi$  and the stresses are given.

E. G. Chilton, USA

**3237. Bisplinghoff, R. L., Further remarks on the torsional rigidity of thermally stressed wings**, *J. Aero/Space Sci.* **25**, 10, 657-658 (Reader's Forum), Oct. 1958.

Author presents both theoretical and experimental result for the torsional rigidity of a long uniform plate subjected to a chordwise temperature distribution. Effect of large deflection is taken into account in the analysis. The torsional rigidity is expressed in terms of two parameters: (1) temperature differential between the edge and the center of the plate, (2) rate of twist. Close agreement between the theory and experiments is indicated.

T. H. H. Pian, USA

**3238. Galletly, G. D., On axisymmetric thermal stresses in thin shells of revolution**, *J. Aero. Sci.* **25**, 3, 201-202 (Reader's Forum), Mar. 1958.

**3239. Ignaczak, J., Thermal displacement in a non-homogeneous elastic semi-infinite space caused by sudden heating of the boundary** (in English), *Arch. Mech. Stos.* **10**, 2, 147-154, 1958.

This paper discusses the mathematical steps necessary to obtain a nonsteady field of thermal displacement in a nonhomogeneous semispace. This generalization may be useful to describe the phenomenon of wave motion caused by sudden heating of the

edge of a multilayer elastic semispace constituting a case more nearly approaching the reality. The paper is divided into three parts; (1) Statement of problem, (2) the heat conduction problem, and (3) solution of the problem. The Laplace transformation is used to solve the problem. Borel's theorem on the convolution of two functions is also used to perform inverse transformations.

G. R. Fusner, USA

**3240. Grechushnikov, B. N., and Brodovskii, D., Thermal stresses in cubic crystals** (in Russian), *Kristallografiya* **1**, 5, 597-599, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11876.

An investigation is made of the plane deformation of an unevenly heated elastic anisotropic body, possessing at least one plane of elastic symmetry. The general equations of plane deformation are derived on the assumption that spatial forces are non-existent, while temperature  $T$  appears as a linear function of time and depends on coordinates  $x, y$ . The authors show that the problem set merges with the problem on the plane deformation of a similarly but evenly heated body on which spatial and surface forces are reacting, related in a determined way to temperature  $T$ . As an example an examination is carried out on an unevenly heated round cylinder, cut out of a crystal belonging to the cubic system. An elementary solution was found to cover this case; the stress components were determined as polynomials of the second degree relatively to coordinates  $x, y$ .

S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3241. Lekhnitskii, S. G., A few cases of elastic equilibrium in anisotropic plates with noncircular apertures (plane problem)** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22**, 160-187, 1955.

**3242. Krylov, V. V., Some questions arising in the general investigation of the equilibrium of an elastic body** (in Russian), *Trud. Kazansk. Aviat. In-ta* **31**, 447-615, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11859.

Author has as his objective the carrying out of a general investigation of the stressed and deformed state of an isotropic elastic body and the deriving of equations on the theory of elasticity, without recourse to some assumptions regarding the smallness of the changes of position or their derivatives. The study is arranged under seven headings: 1) Deformation of a continuous medium, 2) Analysis of the stressed state, 3) Basic relations (between the tensors of stress and deformation), 4) Integration of equations of equilibrium, 5) Pure deformation in a point, 6) Plane problem, 7) Torsion of a round cylindrical shaft. The broad features given in the paper for the setting up of a nonlinear theory of elasticity leads to the consideration of the following aspects: a) the unsymmetrical tensor of deformation must be determined by means of nine components: "the sum total of the combined angles of rotation of the two linear elements (i.e. shear) does not appear to be necessary," "the study is compelled by its development to accept the opinion that the attracting of each item (from which the expression of shear is composed) as an independent component of the tensor of deformation makes the investigation more simple;" b) the experimental relation between the stresses and deformations is accepted in the form of Guk's principle, that is the linear relation of the relative elongations in the principle directions from the principal normal stresses; c) in all the investigation the versor of deformation actively takes part in the role of an independent tensor. For its determination supplementary equations are required and "it appears the deduction can be made that the customarily accepted basic equations for the theory of elasticity are insufficient for the more exact determination of the stressed-deformed state of an elastic body." However, "the

determination of the vector of deformation is left open in the study."

A. I. Lur'e

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3243. Hamburger, L., Dinca, F., and Manea, V., On the torsion of cylindrical bars** (in Russian), *Acad. Repub. Romine Rev. Mecan. Appl.* **3**, 2, 85-94, 1958.

Authors discuss the torsion of cylindrical bars of simply connected cross section whose boundary is formed by two flat curves which intersect at two different angles (the corresponding profiles are met with in the construction of turbine blades). The function giving the conformal mapping of the interior of the unit circle on the interior of the above-mentioned cross section is constructed. A method of approximation is given for the case in which Schwartz's integral cannot be performed under a finite form. Paper also includes interesting applications.

P. P. Teodorescu, Roumania

**3244. Manea, V., Torsion of external radially grooved crankshafts** (in Roumanian), *Studii si Cercetari Mecan. Appl.* **9**, 2, 423-433, 1958.

Computation of the torsion of external radially grooved crankshafts is reduced to a set of infinite linear algebraic equations by means of certain series development. Both the crankshaft rigidity and the shear stresses that occur are calculated. Results are applied to two particular cases.

P. P. Teodorescu, Roumania

**3245. Dinca, F., and Boicu, N., On the torsion of cylindrical beams of doubly-connected cross section** (in Roumanian), *Studii si Cercetari Mecan. Appl.* **9**, 3, 733-739, 1958.

Solution is given for the torsion of cylindrical beams of doubly connected cross section when the function that yields the conformal mapping of the cross section on a circular rim is previously given. Numerical applications for the domains bounded by regular polygons are included.

P. P. Teodorescu, Roumania

**3246. Schmidt, D., Loading of turbine disks due to centrifugal force and temperature gradients**, *Escher Wyss News* **30/31**, 40-44, 1957/1958.

Only alterations in shape within the elastic zone with a constant modulus of elasticity starting from the unstressed state of the disk at zero speed and constant temperature distribution are taken into account. With the aid of an example in which combined stresses resulting from centrifugal force and temperature gradient are encountered, it is shown which parts of the rotor are subjected to the highest tension and compression stresses and at which local temperatures. In connection with the long-time tensile strength values of conventional ferritic and austenitic steels, the danger of rupture is discussed for the uncooled disk during heating and for the cooled disk with a constant temperature distribution.

From author's summary

## Viscoelasticity

(See also Revs. 3262, 3311, 3341, 3361, 3391, 3429)

**3247. Weertman, J., Dislocation model of low-temperature creep**, *J. Appl. Phys.* **29**, 12, 1685-1689, Dec. 1958.

A low-temperature dislocation creep model of the exhaustion type is proposed to account for the temperature-independent activation energies which are found in recent experiments. Logarithmic creep can be obtained from the model if a Gaussian distribution function of Frank-Read sources is assumed. The theory is applicable under easy glide conditions but should not be used

when extensive double glide occurs. The theory can be extended into the liquid helium temperature range with the aid of Glen-Mott quantum-mechanical dislocation tunneling.

From author's summary

**3248. Odqvist, F. K. G., Engineering theories of metallic creep**, (in English), Symposium su la Plasticita nella Scienza delle Costruzioni, held at Villa Monastero, Varenna, Italy, Sept. 1956, 12 pp.

**3249. Fraifeld, S. E., The fundamental postulates of the equations of the mechanical state of real substances** (in Russian), *Trudi Kharkovsk. Inzh.-stroit. In-ta* no. 4, 15-69, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9451.

A detailed investigation is presented (principally concerned with hysteresis phenomena in concrete) of the fundamental postulates of the mathematical analysis of unbalanced deformation (strain) processes. It is assumed that the principle of strain application (applied strain)

$$\Delta \epsilon(t) = \Delta \epsilon_M(s) + \Delta \epsilon_n(s, t) \quad (1)$$

applies, in which  $\Delta \epsilon(t)$  is the strain increment at the time instant  $t$ , caused by the stress increment  $\Delta \sigma(s)$  at the time instant  $s < t$ ;  $\Delta \epsilon_M(s)$ , the instantaneous strain increment, which is constant for  $t > s$ ;  $\Delta \epsilon_n(s, t)$ , the hysteresis strain increment at the time instant  $t$ , produced by  $\Delta \sigma(s)$ . It is assumed that:

$$\epsilon_M(s) = f[\sigma(s), \theta_0 + s]$$

where  $\theta_0$  is the initial age of the material.

The simple hysteresis strain  $\bar{\epsilon}_n$  is defined as the strain deformation developed during the time following the application of an instantaneous load, thenceforth remaining constant. For such cases

$$\bar{\epsilon}_n = P_0[\sigma(s), t - s]$$

where the stress  $\sigma$  is applied at the instant  $s$ . The time is counted from the start of the preceding load, i.e., possible antecedent phenomena are allowed for. It is further assumed that: (1) The hysteresis strain developing after stabilisation of the applied stress at a particular time instant  $s$  does not depend on the conditions of the antecedent loading case, but only on the constant stress value  $\sigma(s)$ , and the strain  $\epsilon(s)$ , set up at the instant of stress stabilisation; (2) The hysteresis strain counted from a particular time instant ( $s$ ) and due to the application of the stress  $\sigma(s)$ , stabilised at the time instant  $s$  and maintained at a further constant value, depends only on the magnitude of this constant stress  $\sigma(s)$  and the time  $s$ , elapsed from the start of the antecedent loading.

Thus

$$\epsilon_n(s, t) = P[\sigma(s), t, s, \theta_0 + s] \quad (2)$$

and the following relationship can be established between the hysteresis strains and the simple hysteresis strain:

$$P[\sigma(s), s, t, \theta_0 + s] = P_0[\sigma(s), t, \theta_0] - P_0[\sigma(s), s, \theta_0] \quad (3)$$

From the assumptions made, the author develops the following differential equation for the unbalanced strain condition:

$$\frac{d\epsilon(t)}{dt} = \frac{1}{E'(\theta_0 + t)} \frac{d\sigma(t)}{dt} + \frac{\partial}{\partial t} P_0[\sigma(t), t, \theta_0] \quad (4)$$

where  $E'(\theta_0 + t)$  is the local strain modulus at age  $\theta_0 = t$ .

This equation is applicable for determining stresses under particular strain conditions, on the condition that the instantaneous strain and the simple hysteresis strain depend linearly on the stress; in such case, Eq. (4) is linear.

Relaxation problems are given detailed treatment. A solution is given for the problem of determining the stress from given strain

conditions when relaxation characteristics of the material are known.

The latter part of the paper analyses the problem of the conceptions of balanced and unbalanced strain phenomena, and the existing, different theories. The author considers the equations of the theory of plasticity developed by Saint-Venant, von Mises and Reuss, as obsolete; this is an erroneous conclusion, since the Reuss equations,—and their particular case, the Saint-Venant—von Mises equations—are substantially independent of time, and are in complete agreement with the thermodynamic theory on reversible equilibrium processes. The author gives a negative assessment of Boltzmann's hysteresis theory, as well as the equation developed by N. M. Belyayev, the strain-hardening theory and diagrams of Nadai, in the theory of the creep of metals. The author's statements in this regard are debatable.

L. M. Kachanov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3250. Jacobowitz, J. L., and Mader, C. K., Steady-state creep analysis of the weight loadings of furnace tubes on multiple supports, Trans. ASME 81 B (J. Engng. Indust.) no. 2, 115-125, May 1959.**

Analysis is made to determine maximum allowable tube spans under the effects of pressure, uniformly distributed load and symmetrical heat input. The maximum shear theory and Bailey's original method of utilizing secondary creep rate are used as a basis for the analysis. Authors conclude that, in general, allowable spans are greater than those permitted by customary empirical rules. The limiting deflection was taken as two times the inside diameter.

M. Holt, USA

**3251. Goldin, R., Thermal creep design criteria, Aero. Engng. Rev. 16, 12, 36-41, Dec. 1957.**

Author reviews the design criteria which dictate the physical size and shape of structural parts when subjected to normal and elevated temperature service conditions. The basic material characteristics are divided into four categories; (1) yield, (2) ultimate, (3) fatigue, and (4) rigidity. The physical properties and desired measurements are described.

Distortion in engineering structures must be kept below that which shall be noticeable upon inspection. Thus arbitrary amounts of permanent strains have been adopted for various types of loading. The associated laboratory test criteria to verify adequacy of structures are defined.

The factors of safety for various types of loading are discussed in conjunction with aircraft design practice.

M. J. Manjoine, USA

**3252. Kachanov, L. M., Creep in oval and variably walled pipes (in Russian), Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk no. 9, 65-71, Sept. 1956.**

Author develops general equations for steady creep in tubes. To simplify the equations which are written in terms of a stress function  $\Phi$  it is assumed that

$$\Phi = \Phi_0 + \lambda \Phi_1$$

Here  $\Phi$  is the true stress function,  $\Phi_0$  the function for a circular cross section of inside radius  $a$  and outside radius  $b$ ,  $\lambda \leq 0.075$ , a parameter expressing ovality or nonuniform thickness, and  $\Phi_1$  an unknown function.

Solutions for  $\Phi_1$  are obtained for inner and outer surfaces described by the following radius vectors at angular position  $\phi$ .

- (1)  $a(1 + \lambda \cos \phi)$ ;  $b - a \lambda \cos \phi$
- (2)  $(1 + \lambda \cos 2\phi)$ ;  $b + a \lambda \cos 2\phi$
- (3)  $a(1 + \lambda \cos 2\phi)$ ;  $b(1 + \gamma \lambda \cos 2\phi)$ ,  $\gamma \leq 1$

With  $\Phi$  determined it is then possible to calculate the circumferential creep rate in case (1) or the decrease of oblateness with time for cases (2) and (3).

I. Finnie, USA

**3253. Koch, W., Schrader, A., Krisch, A., and Rohde, Helga, Changes in the structure of austenite steels in creep-rupture tests (in German), Stahl u. Eisen 78, 18, 1251-1262, Sept. 1958.**

Authors investigated creep test specimens taken from austenitic chromium-nickel steels with additions of titanium, or niobium and molybdenum and niobium, respectively, with testing times up to 50,000 hrs at 600 to 700 C. The reactions of the carbides and intermetallic compounds during the tests were further studied by means of chemical separation methods, micro-analysis and determinations of the lattice structure as well as of examinations of the microstructure using the electron microscope. Conclusions to be drawn, particularly as regards the correlations between the course of reactions, stress and rupture are stated.

From authors' summary

## Plasticity

(See also Revs. 3248, 3251, 3288, 3303, 3363, 3429)

**Book—3254. Hodge, P. G., Jr., Plastic analysis of structures, New York, McGraw-Hill Book Co., 1959, xiv + 364 pp. \$10.50.**

Book presents the techniques in the analysis of structures beyond the elastic limit and the conditions under which a plastic analysis is appropriate, safe and economical. Structures treated include beams, frames, shells, plates and slabs under static and variable loadings, including dynamic effects. Two basic theorems are emphasized which enable lower and upper bounds on the loading capacity to be determined by independent consideration of static and kinematic conditions respectively. Book has two parts: Part I treats in detail the application of plastic methods to *Bending of beams and frames*, and also deals with elastic-plastic deformations, variable and repeated loading, and direct procedure of design. Part II is primarily concerned with *Combined stresses* in beams, circular plates and cylindrical shells. A brief introduction to some of the problems encountered in the dynamic loading is included. At the end of each chapter problems with examples are thoroughly discussed. Extensive bibliographies and references are given.

J. J. Polivka, USA

**3255. Yoshimura, Y., Comment on the slip theory of Batdorf and Budiansky, Bull. JSME 1, 2, 109-113, June 1958.**

Paper compares the characteristic shear function resulting from the incremental strain theory of plastic flow and the slip theory of Batdorf and Budiansky [NACA TN 1871, 1949; AMR 2, (1949), Rev. 1264] by reference to experiments in tension and torsion. It is concluded that the slip theory is not valid quantitatively for general loading purposes but has significance in particular cases.

P. W. Whitton, England

**3256. Korotkov, V. I., Influence of plastic deformation on the modulus of elasticity of steel of low carbon content (in Russian), Fiz. Metallov i Metallovedenie 2, 1, 160-167, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 12220.**

The dependence was studied of Young's modulus (E) and shear modulus (G) on the degree of cold plastic deformation. The measurements for both the moduli of elasticity were carried out on the same cylindrical sample, to which, with the aid of electromagnetic exciters, either longitudinal or torsional vibrations were imparted; the natural frequency of vibration of the rod was determined by resonance. The material used in the investigation was steel 20 and steel 30 in the form of thin rods, which in the course of drawing attained various sizes; the samples of steel 30 were step-annealed

at temperatures between 200 to 900°, with measurements of the moduli after each step. It was found that with increase in the degree of shrinkage from 0 to 70% Young's modulus invariably decreases (for steel 20 to 6.5%), the shear modulus decreases to start with and then increases a little (by 1.2%), Poisson's ratio drops (by 32%) and the density decreases slightly (by 0.4%). With increase of the annealing temperature the influence of the degree of shrinkage on the value of moduli E and G decreases. The results obtained are explained by the combined action of several factors: the appearance, as the result of cold work, of distortions in the crystalline lattice, and also of micro-voids, reduced the value of both moduli of elasticity and reduces the density of the metal; the filling of the micro-voids increases the density; the emergence of a grain structure somewhat increases the values of moduli E and G. Special tests demonstrated the fact that the values of moduli E and G are not dependent on the grain size. B. S. Ioffe

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Translation, courtesy Ministry of Supply, England*

**3257. Likhachev, Yu. I., The causes of large plastic deformations during tensile tests of specimens with ring-shaped notches (in Russian), *Zh. Tekh. Fiz.* 26, 8, 1841-1848, Aug. 1956.**

Paper concerns the boundary between the plastic region appearing during the tension of a test-piece with a notch. Author disputes G. W. Uzik's statement that the plastic region occurs in the plane of minimum cross-sectional area and has a very small thickness, of the order 0.05-0.1 mm. On the basis of the diagram representing a family of curves with the same value of the shear stress, determined for the elastic state on the basis of Neuber's work, author tries to draw some conclusions on the form of the boundary of the plastic region, using the statement that both families of curves have similar form. Hence, the conclusion that with small radii of curvature of the notch the maximum width of the plastic region measured in the axial direction does not appear in the plane of minimum cross-sectional area but a little above and below that plane. With a certain value of the tensile force the limit of the plastic zone reaches therefore the axis of the test piece at two points lying on both sides of the above plane, and between both plastic zones there remains a nonplastic nucleus. To justify this statement, author points out, among others, the agreement between the value of the force, obtained theoretically, for which the material becomes plastic at two points of the axis of the test piece not lying in the plane of the notch, and the value of the force corresponding to the breaking point of the strain curves obtained experimentally. Z. Marciniak, Poland

**3258. Rakovshchik, Yu. A., Some problems of solving the inverse problem of applied plasticity (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 168-171, May 1956.**

Author discusses certain errors committed by R. A. Miezlumian in his work, "Inverse problems of applied plasticity and the load-carrying capacity of a structure of strain-hardening material," *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 12, 1955. In the case of one-axial bending and torsion of a circular bar, the assumption of plane cross sections is valid only in the elastic phase. If plastic regions occur, in which the material flows, the excess of load is carried by the elastic core only. The elastic core not being circular, the cross section undergoes warping.

The completion of the limit load of statically indeterminate beams given by Miezlumian is valid only in the case of a perfect elastic-plastic material without strain hardening. Only in the case of a distinct "plastic platform" can we assume that the occurrence of the plastic state in the entire support cross section, or, in other words, the appearance of a so-called plastic hinge, makes the beam become statically determinate, while it carries the excess of load.

On the example of a statically indeterminate two-span beam, author shows the values of the load cannot be obtained directly on

the basis of deformations or stresses assumed in the plastic state. The solution may be found only by the iteration method.

D. Niepostyn, Poland

**Book—3259. Fisher, J. C., Johnston, W. G., Thomson, R., and Vreeland, T., Jr., Dislocations and mechanical properties of crystals (Proceedings of Conference, Lake Placid Sept. 6-8, 1956), New York, John Wiley & Sons, Inc., 1957, xiv + 634 pp. \$15.**

Book reports proceedings and discussion of a small international conference on the relationship between dislocations and mechanical properties. Much research in progress at the time of the conference is included as well as some thorough reviews of specific fields.

The first section covers the direct observation of dislocations. For instance Amelinckx describes theory and practice of a decoration mechanism for the microscopic observation and dislocation patterns in transparent crystals. Gilman and Johnston describe experiments suggesting dislocation nucleation at stresses as low as 1 kg/mm<sup>2</sup>, an interpretation questioned by some discussors.

The third section (work-hardening and recovery) contains a comprehensive paper by Seeger on the mechanism of glide and work-hardening in face-centered cubic and hexagonal close-packed metals. Seeger gives a theoretical picture of the dislocation processes governing the plastic properties of these metals and shows how this picture accounts for most experimental observations on single crystals and pure metals and dilute alloys as well as for some of the observations in polycrystals.

The six remaining sections contain mostly shorter papers on deformation of pure single crystals, yield-point phenomena, dislocation damping and fatigue, theory of dislocations, and whiskers and thin crystals, and radiation damage. S. Gratch, USA

**3260. Hoffman, G. A., The structural exploitation of the strength of "whiskers", Rand Corp. P-1149, 25 pp., Aug. 1957.**

Study considers methods of utilizing high strength of fine crystalline filaments ("whiskers") by combining them into cables and sheets. Theories and experiments of whisker strength are reviewed in relation to strength-diameter ratio and dependence on modulus of elasticity. Weight reductions to one-fifth of conventional materials appear possible and provide challenge to further research on subject. G. G. Meyerhof, Canada

**3261. Miletkovskii, I. E., A possible condition of plasticity of an anisotropic body (in Russian), Investigations in the matter of construction-mechanics and theory of plasticity, Moscow, 1956, 169-179; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11969.**

As a condition of the plasticity of an incompressible anisotropic body the hypothesis is discussed of the constancy of the specific energy of the change of form. It is postulated that the elastic and plastic constants are interlinked in a predetermined manner, which to a known degree delimits the application of the proposed condition. The results obtained are not compared with analogous results of other authors. M. Sh. Mikeladze

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**3262. Makogon, M. B., The deformability of alloys in the metastable state (in Russian), *Fiz. Metallov i Metallovedeniye* 1, 2, 246-250, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9726.**

Results are described of experiments on the influence of the rate of deformation (from 0.5 mm/min to 1 m/sec), and the test temperature (+20° to -50°), on the resistance to plastic deformation in compression of duralumin, under different conditions of disequilibrium of the solid solution.

Experimental curves are presented, indicating that the resistance to deformation of duralumin in the metastable state decreases with increasing rate of deformation; in the equilibrium state (after annealing or after completed artificial aging), an increase in the

rate of deformation is accompanied by a normal increase in the resistance to deformation.

Decreasing the test temperature increases the resistance to plastic deformation in the equilibrium state; in the metastable state, the effect varies according to the rate of deformation.

S. I. Ratner

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3263. Kobrin, M. M., The measurement of deformation by means of a clamping ring, in the investigation of residual stresses by the Sachs method** (in Russian), *Zavod. Lab.* **21**, 10, 1229-1235, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9812.

A method is suggested for determining residual stresses, founded on the change in strength of a press-fitted shaft possessing residual stresses. The method is applicable to the determination of both tangential and radial residual stresses. In practice, two systems are recommended: a clamping ring with press-fitting, and a clamping ring in conjunction with torsion. In both cases, the total effect of two separate processes, taking place in the machining of a press-fitted shaft, is determined: (1) the decrease in fitting pressure during machining and the consequent weakening of the press-fit itself, independently of the presence or absence of residual stresses in the shaft; (2) the diametral deformation of the shaft resulting from removal of the residual stresses by machining. These deformations depend on the initial character of the distribution of the residual stresses over the cross section.

The method described enables the values required for introduction into the Sachs formula of the deformation of the cross sections with progressive removal of layers by machining, in the absence of high-sensitivity measuring instruments, using an ordinary micrometer, a press fitted with a dynamometer, or a machine for static torsional testing.

L. M. Shkol'nik

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3264. Solridonov, A. A., and Visslobokov, V. P., Residual stresses after different work-hardening treatments** (in Russian), *Collected papers, Uralsky Politekh. Inst.* no. 63, 15-20, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9727.

The residual stress in the surface layers of samples of steel 45 are determined after spark-hardening, ball-peening, and combined treatment by both methods. The residual stresses were determined by N. N. Davidenkov's method, by progressive etching and strain measurements. The samples were in the form of rings with an external diameter of 82.5 mm, internal diameter 72.5 mm, and width 15 mm. The electric spark treatment was applied with  $G = 100$  microfarads,  $U = 95$  volts,  $I_k = 10$  amps,  $v_{det} = 5$  m/min,  $s = 0.08$  mm/rev. Ball-peening was carried out with  $v_{det} = 34.6$  m/min,  $v_{disc} = 1432$  m/min, tension  $i = 0.2$  mm, feed  $s = 0.04$  mm/rev.

After spark treatment, considerable tensile stresses are set up in the surface layers, reaching, in the layer at a depth of 25 microns, up to 380 kg/mm<sup>2</sup>. Ball-peening sets up compression stresses; in the tests made, the compression stresses extended to a considerable depth, and had a value of 70-80 kg/mm<sup>2</sup> at a depth down to 1 mm (etching was not carried on beyond this depth). In the region between 30 and 100 microns, a significant decrease in the compression stresses is found. Successive strain-hardening by sparking treatment and ball-peening led to the appearance in the near surface layers of appreciable compression stresses (of the order of 70-75 kg/mm<sup>2</sup>), some decrease in the values of these compression stresses being observed in a narrow belt between 40 and 70 microns below the surface.

L. M. Shkol'nik

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3265. Kuklin, L. G., and Perfil'yev, G. L., Methods of measuring the residual stresses in the surface layer of machined parts**

(in Russian), *Zavod. Lab.* **22**, 11, 1350-1352, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9688.

The improvements in the method of measuring the residual stresses in the surface layer of rings consist in reducing the possible errors in the measurement of the deformations (strains) of the investigated rings, and reducing the difficulties of the measurements themselves. For the measurement of small displacements of the ends of a continuously deformed (by removal of the external layers by electrolytic polishing) split ring, instead of the wire strain gages usually employed, a remote-reading indicator of linear displacements with a vibrating probe is used. The principle of action of this teleindicator is founded on automatically recording the amplitude of vibration of the probe, bounded by the surface whose displacement is to be measured. The teleindicator insures stability of the indications, independent of the voltage fluctuations in the circuit feeding the vibrator electromagnet. The teleindicator gage is hermetically sealed.

L. M. Shkol'nik

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3266. Crane, E. V., and Wagner, W. S., High-range plasticity of metals beyond normal work-hardening**, *Trans. ASME* **81 B** (J. Engng. Indust.) no. 2, 178-182, May 1959.

**3267. Shemiakin, E. I., Lamb's problem for a medium with elastic after effects** (in Russian), *Dokladi Akad. Nauk SSSR* (N.S.) **104**, 2, 193-196, Sept. 1955.

**3268. Fel'dman, M. R., Longitudinal deflection of a rod with consideration for the plastic after effect** (in Russian), *Izv. Akad. Nauk ArmSSR. Fiz.-Matem., Estestv. i Tekh. Nauk* **9**, 1, 75-86, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10893.

The problem is examined of the longitudinal deflection of a hinge-supported rod of rectangular section in conditions of creep. It is assumed that the relation between the stresses and the deformation, during momentary deformation, is nonlinear and that the limit of yield depends on the time the load remains applied. The relation of stress to deformation is approximately expressed by two fragments. For deflection  $y$ , with the customary assumptions, an integral differential equation is obtained

$$\frac{\partial^2 y}{\partial x^4} + q^2 y - \int_0^t R(t-\tau) \frac{\partial^2 y}{\partial x^4} d\tau = 0 \quad [*]$$

where  $q$  is the parameter of loading,  $R(t-\tau)$  the function characterizing the property of the material, with time. The solution of equation [\*] is sought in the form of a series. The correlation between time and the critical force is looked for from the boundary conditions.

S. A. Shesterikov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3269. Alexander, J. M., An analysis of the plastic bending of wide plate, and the effect of stretching on transverse residual stresses**, *Instn. Mech. Engrs., Prepr.*, 15-26, 1958.

Paper is presented in two parts. Part I shows a geometric method for solving bending of ideally plastic wide beam. Part II is a demonstration of using method of Part I for estimating effect of stretching on residual stresses which are transverse to stretch direction. Author shows that stretching transverse to major residual stresses is almost as effective in reducing them as stretching in a parallel direction. Curves for rapid estimates of bending moments and spring-back in wide plates of an aluminum alloy are given.

J. Frisch, USA

**3270. Parkes, E. W., How to cross an unsafe bridge—a diversion in dynamic plasticity**, *Engineering* **186**, 4835, 606-608, Nov. 1958.

Author examines a bridge of rigid-plastic material, which will collapse under a mass  $M_s$  placed stationary at its center, and proves that a vehicle whose mass exceeds  $M_s$  will not cause collapse, only great permanent deformations, if moving across the bridge with certain speed. Relations are given between loads and speeds needed to limit the deformations (final slope) of the bridge to a reasonable value. It is shown that the overload cant exceed 22.77%. Author neglects the mass of the bridge compared with that of the vehicle and assumes that plastic moment is independent of the rate of strain. The result obtained can be considered as an approach for the case of mild steel bridges with short spans.

O. Halasz, Hungary

## Rods, Beams and Strings

(See also Revs. 3229, 3243, 3245, 3250, 3268, 3314, 3317, 3326, 3403, 3639)

**3271. Vishnevetsky, G. D., The elastic equilibrium of a cylindrical bar in a medium resisting friction** (in Russian), *Nauch. Trudi Leningrad Inzh.-stroit. In-ta* no. 23, 154-170, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9272.

The stress-condition of an axially-symmetrical, solid cylinder (bar) is examined when exposed to shearing stresses on the lateral surface. It is assumed that the shear stresses due to frictional forces are proportional to the axial displacement of the point

$$\tau = -\kappa q w \quad [1]$$

where  $\kappa$  = coefficient of proportionality (frictional modulus), and  $q$  = pressure on the surface of the bar.

The stress function is written in the following form:

$$\varphi = (A \sin \beta z + B \cos \beta z) [\eta \beta r I_1(\beta r) + I_0(\beta r)] \quad [2]$$

the coefficient  $\eta$  being determined by the condition of absence of radial stress  $\sigma_r$  on the lateral surface of the cylinder, ( $r = b$ ). The author does not point out that the last-named condition contradicts Eq. [1], according to which it should be written

$$\sigma_r(b) = -q$$

Actually, the solution obtained by the author relates to the case, when

$$\tau = -kw, \quad q = 0 \quad [3]$$

in which  $k$  = coefficient of proportionality. The parameter  $\beta$  in Eq. [2] is determined from the condition [1], which leads to a transcendental equation. The constants  $A$  and  $B$  are found from the condition:

$$N = 2\pi \int_0^b r \sigma_r dr$$

where  $N$  is the resultant of the external forces on the ends of the bar.

The shear stresses on the ends of the bar are not determined. Solutions are given for the following problems: (1) A cylinder of finite length is extended by axial forces applied to the ends; (2) A semi-infinite cylinder is extended by an axial force; (3) The uniform heating of a cylinder of finite length.

For a small value of the parameter  $\beta b$  ( $\beta b < 0.2$ ), it may be considered that the sections of the cylinder remain plane.

It is pointed out that, for the practical case (a pipeline laid in the soil), the parameter  $\beta b$  is, in fact, small.

Approximate solutions are also given, obtained for the case that the hypothesis of plane sections is initially assumed. These will evidently coincide with the rigorous solutions for (sufficiently) small values of  $\beta b$ .

It should be noted that similar solutions have been investigated in the theory of screwed joints (distribution of the load over the length of the joint). Solutions are given for the problem of heating a cylinder of finite length in a medium the shearing resistance whereof follows the relationship

$$\frac{1}{\kappa_0} \frac{\partial \tau}{\partial t} + \frac{1}{\kappa_\infty} \tau = -q \left( \frac{\partial w}{\partial t} + \lambda w \right) \quad [4]$$

in which  $\kappa_0$ ,  $\kappa_\infty$ , and  $\lambda$  are constants obtained from frictional experiments.

The author does not mention that the solution neglects inertia terms; at the same time, the case is examined when the temperature instantaneously rises to a particular value.

I. A. Birger

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3272. Saveliyev, N. G., The calculation of elastically-supported beams of variable cross section** (in Russian), *Strength, rigidity, stability and vibrational analysis*, Moscow, Mashgiz, 1955, 169-177; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9541.

An analysis is presented of a beam of variable rigidity, supported on a continuous, elastic foundation. The two-dimensional problem is investigated. The deformations of the foundation are evaluated by means of the Flamand formula; the deformations of the beam, by the approximate differential equation of bending. The known function is assumed to be the law of distribution of the reactive pressure along the sole of the beam. The problem is solved by resolving the function of the reactive pressure into an exponential series with calculation of the deformation of the foundation by the Flamand formula, after which the flexibility function of the beam is similarly expanded in a series with subsequent determination of the deformations of the beam by the differential bending equation. The equation of these expressions furnishes an infinite system of equations for determining the values of the function of the reactive pressure.

This method of analysis has been applied to beams of constant rigidity in the works of M. I. Gorbunov-Possadov [*Sb. Fundamentals-troya* no. 8, 1937], and V. A. Florin [*Sb. Gidroenergoproekta*, no. 2, 1937]. The novel feature is the introduction of a variable cross section of the beam. Author has constructed a matrix of the coefficients of the equation.

I. V. Urban

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3273. Westrup, R. W., and Silver, P., Some effects of curvature on frames**, *J. Aero/Space Sci.* 25, 9, 567-572, Sept. 1958.

Some effects of the radial loading due to the combined action of curvature and circumferential stresses in large curvature beams are investigated. The transverse deflection of cap flanges is first determined by the exact theory of plate strips and then by an approximate method. The approximate solution allows general cross-section shapes to be considered. Theory is linear insofar as the stresses at the web-flange junction and the beam curvature are assumed as fixed. Design charts show the variation of "effective" flange area with a curvature parameter. Excellent agreement was obtained between theoretical and experimental values for circumferential stresses.

P. Cicala, Italy

**3274. Izraelit, A. B., The guarantee for positive solutions when making calculations for redundant beams and frames by the method of set forces** (in Russian), *Trudi Vses. Zaochn. Lesotekhn. In-ta* no. 2, 133-138, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12063.

A method is described which guarantees the obtaining of positive solutions for the geometrical characteristics of sections (area, moments of inertia) essential for the calculations of continuous beams and frames by the method of set forces. Analyzing the in-

equality determining the realizable values of the supporting moments, the author gives them a geometrical interpretation, as  $n-1$ -dimensional faces of the forces region in the  $n$ -dimensional space. By intersection of these faces among themselves a closed region of realizable forces is formed, the significance of which permits the planning for redundant beams and frames by means of a regular process. An adequate presentation of the region of realizable forces can only take place for continuous beams having not more than three intermediate supports. The presentation is given for beams having one or two intermediate supports.

P. B. Antonevich

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3275. Vasilyanskas, K., Three-dimensional diagram for the potential energy in calculations of the deformations of beams (in Russian), *Trudi Akad. Nauk LitSSR* 58, 77-91, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12070.**

A method is given for the determination of transpositions in beams with the aid of calculating the volume of a truncated prism, the base of which is the curve of the deflection moments, while the mean height is the corresponding ordinate of the curve of the deflection moments, derived from the unitary force. The proposed method differs very little from A. Vereshchagin's.

A. A. Popov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3276. Chakravorty, J. G., Torsion of a conical bar of transversely isotropic material, *Bull. Calcutta Math. Soc.* 49, 1, 29-32, Mar. 1957.**

A closed solution in terms of elementary functions, exact within the linear theory of elasticity, is obtained for the problem alluded to in the title. The cone under consideration is circular and the axis of elastic symmetry is assumed parallel to the axis of the cone.

E. Sternberg, USA

## Plates, Shells and Membranes

(See also Revs. 3225, 3230, 3232, 3236, 3237, 3238, 3252, 3269, 3309, 3310, 3311, 3315, 3316, 3318, 3323)

**3277. Federhofer, K., Thin circular plate with concentric circular hole with large deflection (in German), *Öst. Ing.-Arch.* 11, 44, 252-256, Dec. 1957.**

For a small hole and low load, it is proved by means of numerical integration of the basic equation that even the use of a single arbitrary coefficient will lead to satisfactory results when the formerly proposed approximation according to Galerkin [K. Federhofer: *ZAMM* 25, 5, 1945; *Öst. Ing.-Arch.* 1, p. 21, 1946] is applied, with the nonlinear expressions of the basic equations being replaced by the values determined by the theory of bending. The heretofore customary method of neglecting the flexural rigidity and of using the values of the membrane theory gives results in which the deflections are too low, while the stress is too high.

G. Sonntag, Germany

**3278. Yu, Y.-Y., Flexural problems of thin plates under lateral loading solved by the complex variable method (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; 6, 378-389.**

In a previous paper [AMR 9 (1956), Rev. 419], author extended Muskhelishvili's complex variable method for solving the biharmonic equation to the nonhomogeneous equation by incorporating into the method the particular integrals representing the lateral load acting on the plate. The purpose of present paper is to

present a more thorough treatment of the various phases of the general flexural problem, together with solutions of some more specific problems of practical interest.

Conformal transformation is first applied to the results developed in the previous paper, which facilitates the use of curvilinear coordinates and, in particular, polar coordinates. The three usual types of boundary conditions are next formulated. Various kinds of lateral loading, both distributed and concentrated, are then discussed. In the case of distributed load on a circular plate, it is shown that the load may be expanded into a Fourier-Bessel series in the complex form. Based upon this result, a general solution is obtained for a clamped circular plate, and a few special cases are treated. To illustrate the use of the results presented for concentrated loads, a problem is solved in which a circular plate supported at the ends of a diameter is bent by a concentrated force at the center. Finally, the solution of a circular ring plate problem is given in which the plate has clamped edges and is subjected to a lateral load of linear distribution.

From author's summary by C. Massonnet, Belgium

**3279. Wah, T., Large deflection theory of elastoplastic plates, *Proc. Amer. Soc. Civ. Engrs.* 84, EM 4 (J. Engng. Mech. Div.), Pap. 1822, 24 pp., Oct. 1958.**

A strip of infinitely long plate is studied under following assumptions: Material is homogeneous, isotropic, obeys Hooke's law until it yields, exhibits no strain-hardening, and has a large range of pure yielding. Hencky-Mises yield criterion is applicable. A cross section of strip behaves elastically until it has yielded right through, from which its resisting moment remains constant and a plastic hinge is formed. Boundary supports are infinite rigid in plane of plate. Deflection may be many times thickness.

Clarkson [TINA 1956, N.-E. Cst. Inst. Engrs. Shipbldrs. 1957] has performed analysis by means of power-series method using two terms in solutions. Author gives solutions in closed form. He calculates deflections and end slopes prior to and after unloading, and residual membrane tension. Comparison with Clarkson's results gives close agreement.

The solutions are expected to yield reasonably good results for ship bulkheads and similar structures. For plates with finite aspect ratio author claims that, for design purpose, plates with aspect ratio  $> 3$  can be considered infinitely long.

E. R. Steneroth, Sweden

**3280. Olesiak, Z., A bent circular plate with linear supports inside the plate region (in English), *Arch. Mech. Stos.* 9, 2, 227-246, 1957.**

Problem is formulated as Fredholm integral equation of first kind. Boundary conditions used for edge are (a) clamped, (b) simply supported, and (c) clamped on portion with simple support on remainder. Linear support inside plate is simply supported. With  $a$  as plate radius, supports studied are (a) straight lines of length  $a/2$ ,  $a$ , and  $3a/2$  through center of circle, and (b) circular arc of radius  $a/2$  and length  $\pi a/4$ . Solution is found by replacing integral with sum and reducing to system of nonhomogeneous linear algebraic equations. Distribution of reaction forces becomes more uniform as length of line support increases.

R. B. McCalley, Jr., USA

**3281. Olisak, W., and Morz, Z., Elastic bending of circular plates with eccentric holes (application of the method of inversion) (in English), *Arch. Mech. Stos.* 9, 2, 125-153, 1957.**

Basic relations of inversion mapping are first established, followed by the treatment of the title problems: (1) With both inner and outer circular peripheries clamped, the plate is subjected either to a uniform load, or a concentrated load, or a uniform load over a circular area. Authors claim that the solution can be extended to a semi-infinite plate and a large plate having two unequal holes, subjected to a concentrated load. (2) With one periph-

ery clamped, the other simply supported, a semi-infinite plate is subjected to a concentrated load.

A numerical example is given for the case of a circular plate with an eccentric hole, subjected to a uniform load.

D. H. Cheng, USA

**3282. Parsons, H. W., The deflection of a normally loaded square plate elastically supported along its edges** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 390-395.

Title of paper is almost misleading as author treats in fact only the case of a partly built-in square plate with no deflections along the edges. For a uniform normal load, an approximate solution is obtained by means of a strain energy method. No numerical examples are presented for this case but the approximate method is tested for the two extreme cases of built-in edges and for simple support, for which exact solutions are known. Paper lacks distinctness in statements, and meaning of some signs is only understood from the contents.

Reviewer points out that this case can be solved exactly by the same method as for the built-in edges, yielding relations between coefficients no more laborious than those of the approximate solution.

Z. Kami, Israel

**3283. Vlasov, V. Z., The method of initial function in problems of theory of thick plates and shells** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 321-330.

The equilibrium equations of three-dimensional elasticity are expressed in terms of displacements and solutions postulated in the form of Maclaurin series. Each displacement component is also expressed as a linear combination of six "initial functions," each multiplying a linear differential operator. These operators are actually infinite series but may be approximated in the case of thick plates or shells by a finite number of terms. Constants appearing in the series are determined from boundary conditions. Discussion is also presented for the case of multi-layered plates with different elastic constants for each layer.

W. A. Nash, USA

**3284. Vinokurov, S. G., Application of Galerkin's method to the solution of the problem of large deflections in a round plate** (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Matem. i Tekh. Nauk.* no. 10, 57-61, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11909.

The problem is investigated of the large deflections of a round plate, loaded with an evenly distributed transverse load and so heated that the temperature changes linearly according to thickness (of the plate). Known differential equations are derived which are solved with the aid of the Bubnov-Galerkin method. The relation of the deflection to the transverse load and temperature was obtained.

V. I. Feodos'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3285. Ol'shak, V., and Savchuk, A., Experimental check of the carrying capacity of plates, Part I** (in Russian), *Bull. Acad. Polonaise Sci. (IV)* **3**, 4, 199-205, 1955; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11986.

Experimental data are furnished dealing with the checking of the theory of the carrying capacity of plates. A qualitative check of the basic position of the theory is presented (the kinematics of the boundary conditions of the plates, the fracture scheme, questions of the flexible-plastic scheme of deformation, etc.), and the solution of this theory for a number of plates with different types of loading. Numerical values are given for the experimental verification of some theoretical solutions (taking into account orthotropy, heterogeneity of the plates). The experiments were carried out on ferro-concrete plates, measuring  $74 \times 74$ ,  $74 \times 144$ ,  $74 \times 214$

cm with a thickness of 3 cm and coefficients of reinforcement equalling 0.25 and 0.505%. The reinforcement of the plates consisted of steel rods 2.2 mm in diameter with a yield value of 2210 kg/cm<sup>2</sup> and relative elongation of about 20% at rupture point. The results of the experiments and their comparison with the theoretical data are given in tabular form.

A. N. Elpat'evskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3286. Sherman, D. I., Concerning one method of solving of torsion, bending and plane elasticity problems for multi-connected regions** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 143-146.

Solution of equation

$$\phi(t) + t \phi'(t) + \bar{\psi}(\bar{t}) = 2f(t)$$

where  $\phi(z)$ ,  $\psi(z)$  are regular in region between two simple contours  $L_1$ ,  $L_2$  having no common points,  $L_2$  entirely surrounding  $L_1$ , and  $f(t)$  is given on  $L_1 + L_2$ , is reduced to solution of Fredholm integral equation. No applications are given but readers are referred to other papers which use this method.

A. E. Green, England

**3287. Postnov, V. A., A particular case of high-amplitude flexure of a centrally-asymmetric plate asymmetrically supported on its constrained edges** (in Russian), *Trud' Leningrad Korablestroito. Inst.* **16**, 21-33, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9327.

The stability in finite bending is investigated of a plate freely supported on three edges and rigidly held on the fourth, on the basis of the v. Karman equations. Flexure is determined by the series

$$w = \sum_{n=1}^{\infty} \sum_{m=0}^{\infty} A_{mn} (\cos \beta_{2m+1} y - \cos \beta_{2m+3} y) \sin \alpha_n x$$

where  $\alpha_n = n\pi/a$ ,  $\beta_k = k\pi/b$ ,  $x$  = direction parallel to the fixed edge;  $y$  = direction perpendicular thereto;  $a$  and  $b$  = length of sides. The boundary conditions for the deflection of the plate at the freely supported edges are satisfied. For this case, the stress function is determined from the equation of compatibility, and its coefficients expressed as quadratic functions of the parameters  $A_{mn}$ .

The equilibrium equation is solved by the Bubnov-Galerkin method, obtaining a system of cubic (third-order) equations determining the required parameters of the deflection  $A_{mn}$ .

As an example, separate calculations are presented for one term of the series ( $A_{mn} = A_{01}$ ). For this case, curves are plotted for the coefficient of reduction of a plate compressed by hypercritical stresses.

G. G. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3288. Colonnetti, G., Elastic plastic equilibrium of a thin plate** (in Italian), *Parti I & II Atti Accad. Naz. Lincei R. C. Sci. Fis. Mat. Nat.* **22**, 1, 3-5, Jan. 1957; **22**, 2, 130-132, Feb. 1957.

**3289. Karas, K., The curvature of cylindrical membrane by hydrostatic pressure. Part II. Inhomogeneous stress and strain** (in German), *Ing.-Arch.* **26**, 3, 157-180, 1958.

Author calculates the stress combination in a membrane of the form of a circular ring loaded in radial direction at the inner and exterior borders. All stresses in the membrane must be positive. Also calculated is the curvature of the membrane, which is in a vertical plane, under a horizontal hydrostatic pressure. The pressure, the stresses and strain are considered as a combination of a uniform part and an antisymmetrical part. Three boundary conditions are assumed: at the inner boundary a fixed circular plate or a free movable or an elastic movable circular plate. For all

these cases the curvature of the membrane is calculated numerically.  
L. Foppl, Germany

**3290. Brombacher, W. G., and Jenny, C. J., Some factors affecting the performance of corrugated diaphragm capsules having a deflection nonlinear with pressure, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958, Pap. 58-A-169, 23 pp.**

**3291. Nyffeler, H., An interesting translation shell (in German), Schweiz. Bauzeitung 76, 49, 735-736, Dec. 1958.**

Paper discusses a translation shell, the calculation of which is exceedingly simple due to its special shaping. This circumstance is particularly noteworthy, seeing that structural practice generally avoids the application of translation shells, because of their complicated calculation.

Author chooses cycloid-like curves as generating curves for the shell. Its load is approached by a double Taylor-series, and the stress function of the problem is put together from parts corresponding to the single load members. The chosen shell form offers the possibility to express these by very simple closed formulas.

The special shell form suggested in the paper and its solution were originally discussed by Reviewer [*Acta Techn. Hung. Budapest* 10, 1-2, 59-71, 1955, and 11, 1-2, 231-240, 1955; *AMR* 9, (1956), Revs. 709, 2168].  
P. Csonka, Hungary

**3292. Mittelman, G., Contribution to the calculations of translational shells (in German), Ing.-Arch. 26, 4, 288-301, Aug. 1958.**

The complete solution for membrane stresses and displacements in an elliptic paraboloid under dead load is given in tensor notation. Approximate values of the shear stresses at the corners are obtained. The bending and twisting disturbances at the boundary are computed under the assumption of a slightly variable thickness. A numerical example compares the results of this theory with those of Csonka and of Flügge.

This is the most complete paper on elliptic paraboloids published to date.  
M. G. Salvadori, USA

**3293. Levi, F., and Goffi, L., Discussion and checking of the flexural calculation of a spherical shell (in Italian), G. Gen. Civ. 96, 1, 10-19, Jan. 1958.**

**3294. Doganoff, I., The dual curvature support with parabolic axis under effect of shell loads (in German), Bautechnik 34, 2, 49-56, Feb. 1957.**

**3295. Flugge, W., and Geyling, F. T., A general theory of deformations of membrane shells (in English), Publ. Int. Assn. Bridge Struct. Engng. 17, 23-46, 1957.**

Before developing a general membrane theory for deformation of shells, authors reviewed the membrane stress problem as originally formulated by A. Pucher ["Über den Spannungszustand in Gekrümmten Flächen," *Beton u. Eisen* 33, 1934].

A partial differential equation is written in terms of the "vertical" deflection membrane forces, and the function describing the vertical height of the surface of the shell. The membrane forces may be specified, e.g., set equal to zero for inextensional deformations, or taken from known membrane stress solutions. Having found the "vertical" deflections, the other components of the deflection may be found by integration of two expressions derived by the authors, or found independently by the solution of two equations of the same general form as that for the vertical deflections.

The boundary conditions considered in this paper are those which the authors have shown to be most applicable to membrane solutions, i.e., boundary conditions prevent slipping of the shell, relative to the shear diaphragm support, but do not prevent movements perpendicular to the shear diaphragm nor perpendicular to the shell at the shear diaphragm. The shells in the form of el-

liptic and hyperbolic paraboloids are investigated both for inextensional and extensional deformations.

The elliptic paraboloid shell is investigated for uneven settling of the corner points and shown to exhibit inextensional deformations for this condition, indicating elliptic paraboloids are insensitive to uneven settlement of the corner supports. Several other interesting results are deduced from the analyses, including the existence of critical, or eigenvalue, conditions on the dimensions of the hyperbolic paraboloid for inextensional deformations.

Authors point out that the membrane theory produces quite acceptable results for the deformation of elliptic paraboloids, but that for hyperbolic paraboloids it is rather limited and generally requires the use of bending theory.  
A. L. Ross, USA

**3296. Favre, H., A method of calculation of cylindrical shells of linearly varying thickness (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; 6, 297-308.**

Solutions for deflections and stresses are found which are applicable to long conduits and similar long structures having one end free and the other constrained in some manner.

The problem is attacked by assuming that the deflections can be expressed by  $w = w_0 + w_1 e + w_2 e^2 + \dots = w_i e^i$ , where  $w_i$  is deflection function and  $e$  is a parameter characterizing the variation of wall thickness. The  $w_0$  and  $w_1$  terms are evaluated and the solution is stopped. The necessary conditions on  $e$  and the length of the conduit  $l$  are presented which assures the validity of the solution when using only these first two terms. Graphs of deflection, slope, bending moment, and shear versus length are given with  $e$  as a parameter. The graphs clearly show that, within the range of applicability of the two-term solution, the thickness variation has small influence on the results. The solutions are applied to eight practical engineering problems.

Reviewer believes the paper would be improved if the author had clearly documented the references he makes to the efforts of others.  
D. W. Breuer, USA

**3297. Nazarov, O. O., Large deflections and the stability of an inclined shell of double curvature, hinge-fastened along all its edges (in Russian), Dopovidi Akad. Nauk URSR no. 4, 349-352, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 11890.**

An examination is made of a doubly curved shell, rectangular in plane, with hinge-fastened edges, under the action of a normally distributed load, giving rise to large deflections. Solving the problem in the first approximation, the author obtained the dependence of load on deflection, determined by the relation of the sides of the panel in plane and the direction of lift. A comparison with other solutions in the literature is not given in the paper.

M. A. Koltunov  
Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3298. Klembovskii, Z., Bases for evaluation of ring-shaped reinforcements in calculations of the strength of a tube subjected to the action of internal pressure (in Russian), Bull. Acad. Polonaise Sci. (IV) 1, 3, 107-111, 1953; Ref. Zh. Mekh. no. 10, 1957, Rev. 11877.**

The results of the author's work regarding the calculations for a ringed tube, working under internal pressure, are briefly described. The case is examined of the snug fitting of the rings without preliminary expansion. The solution of the given problem, as also the basic equations, are known [for instance, S. P. Timoshenko, "Plates and shells," Gostekhizdat, 1948].  
S. N. Sokolov  
Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3299. Shevlyakov, Yu. A., The conditions for single-value displacements in flat, spherical shells (in Ukrainian), Dopovidi Akad.**

Nauk URSR no. 5, 448-450, 1955; Ref. Zh. Mekh. no. 8, 1957, Rev. 9324.

The conditions for single-valued tangential displacements in a flat shell under a transverse load of particular form are stated.

V. G. Rekach

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3300. Onyashvili, O. D., and Shakhramanov, G. S., Evaluation of the boundary effect in the calculation of spherical shells** (in Russian), *Trudi In-ta Stroit. Dela Akad. Nauk GruzSSR* **5**, 55-60, 1955; Ref. Zh. Mekh. no. 8, 1957, Rev. 9316.

An approximate evaluation is given of the stress condition in a flat, spherical shell or envelope, rectangular in plan, depending on the character of the boundary conditions.

By integrating the equation for flat envelopes in the engineering theory of moments, and, by applying the methods of variations, it is proved that the influence of the boundary effect grows with increasing flatness of the shell, and, in the limiting case of the flat plate, reaches a maximum.

V. G. Rekach

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3301. Galimov, K. Z., A method of solving the boundary cases of the equations of flat shells** (in Russian), *Uch. Zap. Kazansk. In-ta* **116**, 5, 19-26, 1956; Ref. Zh. Mekh. no. 8, 1957, Rev. 9301.

For integrating the equations of the theory of flat shells

$$\nabla_{\alpha} \nabla_{\beta} M^{\alpha\beta} + c^{\alpha\gamma} c^{\beta\rho} (b_{\alpha\beta} + \kappa_{\alpha\beta}) \nabla_{\gamma} \nabla_{\rho} \psi = p \quad (1)$$

$$B' \Delta \psi - c^{\alpha\gamma} c^{\beta\rho} \left( b_{\alpha\beta} + \frac{1}{2} \kappa_{\alpha\beta} \right) \kappa_{\gamma\rho} = 0 \quad (2)$$

$$c^{\alpha\gamma} c^{\beta\rho} \nabla_{\rho} \kappa_{\alpha\gamma} = 0 \quad (3)$$

$$\kappa_{ij} = D' (a_{i\alpha} a_{j\beta} - \nu c_{i\alpha} c_{j\beta}) M^{\alpha\beta} \quad (4)$$

$$B' = \frac{1}{Et}, \quad D' = \frac{B'}{t^2}$$

the moment tensor  $M^{ij}$  is put in the form

$$M^{ij} = (a^{i\alpha} a^{j\beta} + \nu c^{i\alpha} c^{j\beta}) \nabla_{\alpha} \nabla_{\beta} \varphi \quad (5)$$

$$\varphi = \sum_{m,n} c_{mn} \varphi_{mn}$$

and the coordinate functions  $\varphi_{mn}$  are stated so as to satisfy nontangential boundary conditions. The solution in the form (5), ensures that the conditions (3) are satisfied with an accuracy commensurate with the theory of flat shells. The  $\psi$  function is determined from (2), with the tangential boundary conditions represented by  $\varphi$ .

Eq. (1) can be satisfied by assuming that

$$M^{ij} = \frac{1}{2} c^{i\alpha} c^{j\beta} (\nabla_{\alpha} \psi_{\beta} + \nabla_{\beta} \psi_{\alpha}) - c^{i\alpha} c^{j\beta} (b_{\alpha\beta} + \kappa_{\alpha\beta}) \psi + M_{(0)}^{ij} \quad (6)$$

where  $\kappa_{ij}$  are determined by Eq. (4) and (5), and  $M_{(0)}^{ij}$  is a particular solution of the inhomogeneous equation (1). Putting the function of the moments  $\psi_j$  in the form

$$\psi_j = \sum_{m,n} A_{mn}^{(j)} \psi_{mn}^{(j)} \quad (j = 1, 2)$$

in which the coordinate functions  $\psi_{mn}^{(j)}$  must satisfy the fulfillment of nontangential boundary conditions, the author suggests by means of the equations (6) to eliminate the coefficients  $A_{mn}^{(j)}$ . A sufficient number of equations can be obtained, for instance, by

Bubnov's method [cf. I. G. Bubnov, Reference in the paper by Prof. S. P. Timonenko: "The stability of elastic systems, Sb. In-ta Inzh. Putey Soobshchanya, 1913, no. 31; Selected Works, Sudpromgiz, 1956, 136-139]. The unused third equation (6), can be used to determine  $c_{ij}$ .

Developed equations are given for calculating a cylindrical panel acted upon by an external pressure for the cases of: (1) rigid constraint; and (2) free edge support; as well as, for the case of uniform tension-compression and external pressure, in which the valid stresses normal to the outline are stated, while the tangential stresses are equal to zero.

N. A. Alumiya

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3302. Laul, Kh. Kh., Cylindrical ferroconcrete shells with cracks in the tension zone, Part I; Cylindrical ferroconcrete shells with prestressed reinforcement, Part II** (in Russian), *Trudi Tallinsk. Politekhn. In-ta (A)* **45**, 1-43, 1953; Ref. Zh. Mekh. no. 8, 1957, Rev. 9612.

The first part investigates the stress conditions in a cylindrical ferroconcrete shell after the appearance of cracks in the tension zone. It is found that this appearance of cracks in the tension zone does not endanger the stability of shells under a load producing a negative bending moment. After appearance of the cracks, the moments decrease slightly. If the load produces positive bending moments, the picture is substantially reversed: the cracks develop considerably, and the values of the moments increase.

The second part discusses a method of calculation recommended by the authors for the analysis of ferroconcrete shells with a prestressed reinforcement arranged in the edge regions. It is assumed that a part of the reinforcement is rectilinear, and the other part, parabolically curved. It is observed that, as a rule, the nonlinearity of the problem can be disregarded. The forces in the shell can be determined by the method of summing the forces arising in the preliminary stressing of the reinforcement with the forces due to the action of the applied load, without considering the influence of the loading forces on the prestressing forces.

L. S. Gil'man

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3303. Tsurkov, I. S., Elastic-plastic equilibrium of shells of revolution with small axially symmetric strains** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 106-110, Nov. 1956.

Paper is based on the theory of small elastic-plastic strains and its applications to shells, described by A. A. Ilyushin in "Plasticity." The shells under consideration are shells of revolution made of an elastic-plastic material, incompressible in the plastic and the elastic-plastic zone, and loaded in an axially symmetric manner.

The object of this paper is to obtain a sequence of functions enabling the approximate determination of forces, moments and displacements. This aim is reached by using Ilyushin's iteration method called by him the elastic solution method.

Expressing the initial equations of the theory of elastic-plastic shells of revolution in terms of Meissner's variables, author obtains an ordinary differential equation of the second order for the complex function required. Contrary to the elastic case, it is a nonlinear equation.

The method of elastic solutions enables author to reduce the problem of solving this equation to the consideration of an infinite sequence of independent linear equations. The first equation of this sequence, corresponding to the elastic shell, is treated as the zero approximation to the elastic-plastic problem. Expressions for the  $n$ -th approximations are given. During the calculation process author introduces certain approximate relations.

As an example a thin-walled tube is considered. It is assumed to be bent with moments uniformly distributed along the end parallel circle. The equations obtained enable the determination of the state of stress and displacement to any required approximation. It is shown that the second approximation gives satisfactory results. The values of the basic quantities and the relations between them are given in the second approximation in the dimensionless form.

J. Rychlewski, Poland

**3304. Vorovich, I. I., On the Bubnov-Galerkin method in the nonlinear theory of shallow shells** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **110**, 5, 723-726, 1956.

**3305. Frenzel, W., and Rothe, H., Theoretical determination of tensile and bending stresses in conveyor belts** (in German), *Faserforsch. u. Textiltech.* **9**, 6, 203-213, June 1958.

During rotation of a conveyor belt around a barrel the superposition of bending stresses in the belt on tensile stresses takes place. Resultant stresses are investigated under assumption that the stress-strain relation of the material of a belt is not linear. Authors assume an analytical approximation of this function in the form  $\sigma = C \epsilon^2$ , containing two parameters: coefficient  $C$  and theoretical unstrained length in  $\epsilon$ , proper selection of which guarantees the agreement of the stress-strain function over a wide range with experimentally obtained curve.

Using formulas developed, the existence of optimal number of reinforcing textile fibers is shown. The increase of number of fibers causes the reduction of tensile stresses while bending stresses rise. In this way maximum obtainable safety factor can be established.

Numerical example is carried out by means of DIN 22101 and by suggested method. Results obtained are compared.

K. Julis, Czechoslovakia

**3306. Shelengovskii, F., Tension by concentrated forces on an infinite disc with a centrally situated rigid round bolt** (in Russian), *Bull. Acad. Polonaise Sci. (IV)* **4**, 3, 155-162, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11871.

Using the method of the theory of the functions of a complex variable a solution of the problem is obtained of the tension on an infinite disk, having a centrally situated rigid round bolt, when under the action of two concentrated forces, placed equidistantly from the central bolt.

A. Ya. Gorgidze

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

## Buckling

(See also Rev. 3400)

**3307. Thurlimann, B., Influence of the eigenstresses upon the buckling of columns** (in German), *Schweiz. Arch.* **23**, 12, 388-404, Dec. 1957.

The presently accepted buckling theories are unable to explain satisfactorily the actual behavior of steel columns in the inelastic range. The possibility of the influence of residual stresses on the buckling load is demonstrated on a simple model.

Actual measurements of residual stresses on rolled shapes, and on welded and riveted members are briefly described. The corresponding results are presented in graphs. Two procedures are explained for the calculation of column buckling curves including the influence of residual stresses. Buckling tests on rolled shapes, welded and riveted columns are in fair agreement with these curves.

The influence of residual stresses on other stability problems in the field of steel constructions is discussed.

It is concluded that due consideration of the residual stresses is essential for a satisfactory explanation of the buckling of steel members in the inelastic range.

From author's summary

**3308. Malyutin, I. S., On the equilibrium of compressed plates beyond the elastic limit** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 118-121, May 1957.

A rectangular plate is bent to a cylindrical surface under the action of a compressive load. To consider the influence of plastic deformation a simplified model of a plate has been introduced. It consists of two rigid slabs joined by a kind of plastic hinge, composed of two thin, narrow and deformable sheets.

Two solutions of the stability problem have been obtained: the first based on the theory of small elastic-plastic deformation, the second on a generalized theory presented by D. Triphan.

After solving the above problem, author passes to the comparison between the obtained results and those obtained by Shanley and Rabotnov for the elastic-plastic stability of compressed columns.

M. Sokolowski, Poland

**3309. Nowacki, W., and Sokolowski, M., Certain stability problems of rectangular plate** (in English), *Arch. Mech. Stos.* **9**, 2, 109-124, 1957.

Critical loads are determined for rectangular plates with simple supports on top and bottom edges and different conditions on vertical edges. Differential equation of buckling is replaced by equivalent integral equation which is replaced in turn by infinite system of secular equations. Buckling condition is found by setting principal determinant of system equal to zero. Procedure is demonstrated by following examples: (a) plate clamped along two vertical edges and loaded uniformly in vertical direction over a segment, (b) plate clamped on vertical edges and subjected to concentrated forces in vertical direction, (c) plate clamped on vertical edges and loaded by horizontal concentrated forces, (d) infinite strip with periodic load, (e) plate simply supported on one vertical edge, clamped on other, and loaded uniformly in vertical direction, and (f) plate simply supported on all edges with uniform and concentrated loads in vertical direction over half of height.

R. B. McCalley, Jr., USA

**3310. Finkel'shtein, R. M., On a problem in the statics of thin cylindrical plates** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 136-140, May 1956.

Simply supported thin cylindrical shell with rectangular projection is considered. Besides an axial load  $p$ , uniformly distributed on the circular sides of the shell, its entire surface is acted upon by a uniformly distributed radial load  $q$ . It is assumed that no moments appear in the shell as long as the loads are below their critical values; the critical load, however, produces large deformations. The problem is reduced to a system of two nonlinear differential equations, the unknown functions being: the radial displacements  $\varphi$  and the stress function  $F$ . After having assumed the form of  $\varphi$  as in the case of small deformations, this function is inserted into one of the differential equations and the function  $F$  obtained. Substituting both functions in the second equation, author obtains a function  $\Phi$ , depending on the coordinates, maximum deflection and the loads  $p$  and  $q$ . He expresses the function  $\Phi$  by Fourier series and, by equalizing its coefficients to zero, the conditions of buckling are obtained.

Z. Kaczowski, Poland

**3311. Bozajian, J. M., Inelastic stability theory for creep buckling of plates and shells under transient loading**, *J. Aero/Space Sci.* **25**, 12, 795-796 (Readers' Forum), Dec. 1958.

Because at the inception of buckling, deformations are rapid compared to the creep rate, author proposes that the dynamic elastic modulus be used instead of the tangent modulus in Gerard's

creep buckling hypothesis [*J. Aero. Sci.* **23**, 879-82, 887; 1956]. A time-dependent secant modulus is also incorporated. The results are said to agree well with tests of cylindrical shells.

A. D. Topping, USA

**3312. Mansfield, E. H., Some identities on structural flexibility after buckling, *Aero. Quart.* **9**, 3, 300-304, Aug. 1958.**

Paper gives some identities concerning the flexibility of certain elastic structures, including flat plates, at the onset of buckling and subsequently. The identities have a useful application in determining the flexibility and the rate of change of flexibility with load for structures in which the mode in the buckled state changes continuously with load.

From author's summary

## Vibrations of Solids

(See also Revs. 3208, 3351, 3374, 3637, 3639, 3640, 3641)

**Book—3313. Pisarenko, G. S., The oscillations of elastic systems in the presence of dissipation of energy in the material (in Russian), Kiev, Izd-vo Akad. Nauk USSR, 1955, 239 pp. + illus.; Ref. Zh. Mekh. no. 8, 1957, Rev. 9396.**

Small oscillations of bar systems possessing internal friction are examined. According to N. N. Davidenkov [*Zh. Tekh. Fiz.* **8**, no. 6, p. 453, 1938], it is assumed that the hysteresis loop is symmetrical with respect to the Hooke (straight-line) curve; it is also assumed that the equation of the envelope curve of the hysteresis loop is a polynomial, while the form of the loop is considered to be independent of the magnitude of the amplitude of deformation. On the assumption that the curves forming the hysteresis loop are flat, author applies the method of the lesser parameter. In this case, the solution is derived for both branches of the hysteresis loop. The frequency and the phase shift angle are determined from the equation of the energy balance for the oscillation case. In this formulation, the transverse oscillations of bars of varying cross section are investigated, as well as the vibrations of (turbine) blades in conditions of unsteady rotation.

A method is suggested for determining the dissipation of energy in the material in the case of free and constrained vibrations, and arrangements for this purpose are described.

Resonance curves for these cases are plotted.

It is found that, when determining the bending deflection, a zero approximation suffices; when the frequency and phase shift are to be determined, the first approximation is adequate.

Book represents the final result of the author's researches, indicated separately in the bibliography.

E. I. Grigolyuk

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3314. Smith, G. M., and Young, L. E., Effect of axial loads on lateral vibrations of a slender member with any degree of end restraint, *J. Aero/Space Sci.* **25**, 9, 596-597 (Readers' Forum), Sept. 1958.**

This brief paper develops an approximate expression for the lowest natural frequency of lateral vibration for a slender bar subjected to an axial load with any degree of symmetrical end restraint. The approximation is accomplished by use of energy methods and LaGrange's equation. Authors employ one assumed shape for any set of end restraints, but let the length of the bar relative to the assumed shape depend on the degree of end restraint. Although this dependence is obvious for the extreme cases of fixed and free ends, the proper length for a given end moment or a given end slope is not clear.

J. C. Wilhoit, USA

**3315. Akasaka, T., and Takagishi, T., Vibration of corrugated diaphragm, *Bull. JSME* **1**, 3, 215-221, Aug. 1958.**

Corrugated diaphragms exhibit greater range of linearity of flexural properties than corresponding flat plates. They are widely used in instruments for this reason and title problem is therefore important.

Authors treat problem as that of an orthotropic plate with corrugations "averaged out." A frequency equation is set up and appropriate expressions are deduced for lowest frequency of symmetric and of asymmetric free vibrations. Allowance is made for a central concentrated mass and effect of edge tension is examined. Theoretical results were found to be in good agreement with experiment when "anisotropy" of equivalent plate is not great.

R. E. D. Bishop, England

**3316. Gazis, D. C., Exact analysis of the plane-strain vibrations of thick-walled hollow cylinders, *J. Acoust. Soc. Amer.* **30**, 8, 786-794, Aug. 1958.**

See errata title source **31**, 2, p. 250, 1959.

Paper gives exact three-dimensional elasticity solutions for vibrations of thick-walled hollow cylinders for case of no axial variation and no axial displacement. Modes are in two groups, no circumferential variation and sinusoidal circumferential variation. First group has two uncoupled families, shear and radial-extensional. In second group these families couple through Poisson's ratio. Only basis of comparison with shell theory approach would be limited to lowest mode of last family, circumferential flexure, and this has not been made.

R. Plunkett, USA

**3317. Sato, K., Effect of the weight of beam on the measurement of Young's modulus by lateral vibration of cantilevers, *Bull. JSME* **1**, 3, 205-209, Aug. 1958.**

Using the Galerkin method, author calculates the frequencies of the fundamental and second modes of the lateral vibration of a cantilever. He presents new formulas for estimating Young's modulus from the experimental result, in which the effect of weight of beam is taken into account, and he compares the calculated Young's modulus obtained from the new formula with the apparent Young's modulus calculated by neglecting the weight of beam.

The result shows that, when the plane of vibration of a beam lies in the horizontal plane, there is very good coincidence between the calculated Young's modulus and the apparent one; when it does not, there is some difference between them depending on the amount of inclination of the plane of vibration.

T. Kanazawa, Japan

**3318. Vorovich, I. I., Bubnov-Galerkin method in the nonlinear theory of vibrations of slightly raked shells (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* **110**, 5, 723-726, Oct. 1956.**

Forced vibrations of a shell of small curvature are considered. Differential equation of the problem contains, in addition to the linear differential operators (with respect to the space-independent variables), the nonlinear ones also. The approximate result is obtained employing the method of Bubnov-Galerkin. The existence and uniqueness theorem of the solution are given.

Z. Kaczowski, Poland

**3319. Tobias, S. A., Non-linear forced vibrations of circular discs—an experimental investigation, *Engineering* **186**, 4818, 51-56, July 1958.**

Periodical force acting on circular disks vibrating at large amplitudes. The disks, which were clamped in the center, were not quite perfect in a mathematical sense. Thus, the angular positions of the nodal diameter were determinable, as was the case with the nodal circles.

Paper discusses vibrations of the 1/0, 0/0, 2/0, and 3/0 (nodal diameter nodal circle) configurations. For each mode of vibration with at least one nodal diameter, there were two nodal positions

which constituted so-called preferential configurations having slightly different natural frequencies. The amplitudes were plotted in diagrams against the applied frequency. At small amplitudes both vibrations were continuous and quite linear. At larger amplitudes a collapse of an amplitude curve indicated that the vibration became nonlinear. One of the two similar configurations involved at the same time a nonlinear traveling wave effect with a smaller amplitude than that of the other, whose nodal positions were uninfluenced by an increase in amplitude. All results were carefully recorded, and are discussed in detail.

S. T. A. Odman, Sweden

**3320. Tameroglu, S., Torsional vibrations of disks with exponential profile** (in German), *Ing.-Arch.* **26**, 3, 212-219, 1958.

The fundamental natural frequency of axisymmetric torsional vibrations for nonrotating disks having an exponential cross section [thickness =  $a \exp \{-(r/c)^p\}$  where  $a$ ,  $c$ ,  $p$  are constants and  $r$  is the radial co-ordinate] is derived. The governing differential equations are given by Biezeno and Grammel ["Technische Dynamik" 1939, Section VIII-15]. Expressing the solution in series form, author works out two numerical examples for disks with fixed boundary conditions at inside radius. The numerical results indicate rapid convergence for disks with ratios of inside to outside diameter less than about 0.20.

N. H. Jasper, USA

**3321. Federhofer, K., Forced vibration of a circular ring** (in German), *S. B. Math.-Nat. Kl. Bay. Akad. Wiss.* **166**, 5, 1-14, 1957.

Forced vibrations are considered of a circular ring with constant cross section under radial loads in its plane. Only strain energy due to bending is taken into account. Solutions are given for a few load systems consisting of discrete or distributed loads.

M. Botman, Canada

**3322. Natanzon, V. Ya., Influence of the oscillations of a framework on the magnitude of the critical velocity of a rotor** (in Russian), *Oscillations in turbo-engines*, Moscow, Akad. Nauk SSSR, 1956, 49-56; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11260.

As a model of the system rotor-stator, an examination is made of a single disk rotor supported by a beam, with its mass evenly distributed along the length of the beam. On this example an investigation is made of the question, important in turbo-construction, of the influence on the critical speed of the elasticity and mass of the stator.

G. I. Nikolenko

Courtesy *Referativnyi Zhurnal*, USSR

Translation, courtesy Ministry of Supply, England

**3323. Naruoka, M., and Yonezawa, M., A study on the period of the free lateral vibration of the beam bridge by the theory of the orthotropic rectangular plate** (in English), *Ing.-Arch.* **26**, 1, 20-29, 1958.

Expressions for the natural frequencies of rectangular plates, which are simply supported at one pair of parallel edges and free at the other pair, are derived; stiffness of the plates is assumed different in the two principal directions. Natural frequency of wide concrete bridges are shown to be determinable by using the results and it is shown that frequencies derived from simple beam theory, in contrast with this plate theory, may be misleading.

D. C. Johnson, England

**3324. Kruszewski, E. T., and Waner, P. G., Jr., Evaluation of the Levy method as applied to vibrations of a 45° delta wing**, *NASA Memo.* 2-2-59L, 21 pp. + 12 tables + 5 figs., Feb. 1959.

The Levy method which deals with an idealized structure was used to obtain the natural modes and frequencies of a large-scale built-up 45° delta wing. The results from this approach, both with and without the effects of transverse shear, were compared with the results obtained experimentally and also with those calculated

by the Stein-Sanders method. From these comparisons it was concluded that the method as proposed by Levy gives excellent results for thin-skin delta wings, provided that corrections are made for the effect of transverse shear.

From authors' summary

**3325. Silveira, M. A., and Brooks, G. W., Analytical and experimental determination of the coupled natural frequencies and mode shapes of a dynamic model of a single-rotor helicopter**, *NASA Memo.* 11-5-58L, 25 pp. + 2 tables + 12 figs., Dec. 1958.

The aim of this investigation is to show experimentally that coupling effects outlined in AMR 10 (1957), Rev. 1348 do exist and that the coupled frequencies and mode shapes can be predicted with good accuracy by analytical approach if the structural properties (mass and stiffness distribution) of the components are known.

The analysis is based on a seven-degree-of-freedom system combining elastic deflections of the rotor blades, rotor shaft, pylon and fuselage; the effect of damping on the coupled frequencies was neglected. The experiments were carried out on a dynamic model (which is fully described) possessing the approximate structural properties of a 1/4-scale model of an existing helicopter. For a given rotor speed the response of the model was measured for a range of exciting frequencies.

The calculated coupled frequencies are compared (1) with the uncoupled frequencies and (2) with the measured coupled frequencies; the importance of the coupled motions is clearly established. The coupled mode shapes are also given. There is good agreement between calculated and measured frequencies and mode shapes, but some differences were noted in the location of the nodal points.

A. W. Babister, Scotland

**3326. Dunham, J., The lowest natural frequency of an axial compressor blade**, *J. Roy. Aero. Soc.* **62**, 573, 677-680 (Tech. Notes), Sept. 1958.

Paper presents simple method for estimating the lowest frequency of flexural vibration of a cantilever beam. Using Rayleigh's principle and postulating the bending moment curve instead of deflections for calculating the strain energy of the beam, author derives a simple formula for the desired frequency. Calculations carried out on several blades show good agreement with experiment. Method is extended to higher modes of combined flexural and torsional vibrations both of shrouded turbine and compressor blades.

V. Kopriva, Czechoslovakia

**3327. Khilchevsky, V. V., Calculation of the vibration of turbine blades of variable cross-section in the presence of rim (shroud) joints, and hysteresis losses** (in Russian), *Izv. Kievsk. Politekh. In-ta* no. 18, 14-30, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9674.

A method is described for plotting the resonance curve of the problem stated in the title, in consideration of the centrifugal forces in the blade masses, connected by any arbitrary number of rim wires. The formulation of the problem of the dissipation of energy in the material, and the method of solution thereof, have been stated by G. S. Pissarenko ["The vibrations of elastic systems in the presence of dissipation of energy in the material"; Kiev, Izd-vo Akad. Nauk USSR, 1955, Chap. 4].

For the case of a single blade in a group, the action of the rim and the root wire respectively is substituted by corresponding bending moments, proportional to the angle of setting, and concentrated forces equal to the inertia forces of the masses of the wire or rim, over the blade pitch. Natural torsion is neglected, the blade being considered rigidly held in the rim of the wheel disk. The center of bending and center of gravity are regarded as coincident, and the vibrations to take place in the plane of least rigidity.

The fundamental equation of the problem is obtained by Hamilton's method. The solution is arrived at by the method of the small parameter, author restricting consideration to the terms containing this parameter in the first order.

A numerical calculation example is given.

E. I. Grigolyuk

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3328. Grigor'ev, N. V., Dynamic dampers for critical conditions in the revolving rotors of turbomachines** (in Russian), Oscillations in turbo engines, Moscow, Akad. Nauk SSSR, 1956, 57-68; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11258.

It is shown that the employment of elastic (linear or nonlinear) elements as supports for the rotor appears to be a useful measure, in many cases, for avoiding the development of resonance conditions. Methods are demonstrated for evaluating the elasticity of the supports when calculating the critical revolutions; a simple graphical method is given for the calculation of the amplitude of the oscillations of a system with a nonlinear elastic element when the work of the rotor is steady; conditions are stated by the use of which the introduction of a non-linear elastic element limits the development of resonance oscillations.

G. I. Nikolenko

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3329. Lowell, C. M., Lateral vibrations in reciprocating machinery**, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-79, 13 pp.

**3330. Gilbert, A. C., A note on the calculation of torsional natural frequencies of branch systems**, *J. Roy. Aero. Soc.* **62**, 572, 599-603 (Tech. Notes), Aug. 1958.

The stiffness matrix of systems whose vibrations are superposed on rigid body motions is singular and therefore matrix iteration cannot be used directly to obtain the fundamental natural frequency. The rigid body modes can, however, be suppressed by introducing conservation of momentum. The modified stiffness matrix can then be inverted and the fundamental mode obtained by iteration. This is well known and was applied to unbranched torsional systems by K. E. Bisshopp [*Quart. Appl. Math.* **3**, 82-84, 1945]. Present paper develops argument for general stiffness matrix and applies it to a branched torsional system.

S. H. Crandall, USA

**3331. Galloway, D. F., Some experiments on the deflections and vibrations of drilling machines**, *Proc. Instn. Mech. Engr.* **170**, 6, 207-231, 1956.

**3332. Tobias, S. A., and Fishwick, W., The vibrations of radial-drilling machines under test and working conditions**, *Proc. Instn. Mech. Engrs.* **170**, 6, 232-264, 1956.

**3333. Sergeev, S. I., The damping of oscillations in machinery** (in Russian), *Trudi Vses. N-i. In-ta Kislod. Mashinostr.* no. 1, 89-101, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11259.

An investigation is carried out of the damping by a linear elastic-viscous damper of a large mass system of the type of a rotor of a turbo-engine, of a crankshaft, etc. Recommendations are made for the selection of the optimum parameters for the damper. The differences are pointed out in the mechanism of dampers for free and constrained oscillations: in the first case the damping proceeds by means of the dissipation of energy in the damper; in the second case the role of the damper consists of alterations, in relation to the frequency of the excitation, in the boundary conditions of the oscillations, which bring about such an excess distribution of the phase correlations between the exciting forces and the

transpositions that the development of resonance phenomena becomes impossible.

G. I. Nikolenko

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3334. Etkin, L. G., A method of determining the dissipation of vibrational energy by the joints and parts of machinery** (in Russian), *Zavod. Lab.* **22**, 12, 1450-1482, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9662.

A description of a diagrammatic layout for an installation to determine the quality of a flanged steel tube under torsional stress. The installation represents a naturally vibrating system, the frequency of vibration of which is determined by the parameters of the mechanical part of the system. In the experiments, the torsional moments  $M_1$  and  $M_2$ , the vibrational amplitude  $\varphi$ , and the phase shift between the moments,  $\psi$ , are measured. The quality factor is  $Q = \pi/\lambda$ , where  $\lambda$  is the logarithmic decrement of the vibrations. This has a small value, in the case of elastic vibrations of the system, according to  $\lambda = \frac{1}{2} \Delta \Pi / \Pi$ . The dissipation of energy in one cycle is  $\Delta \Pi = \pi M_1 \varphi \sin \psi$ . The full energy of vibration at the amplitude  $\varphi$  equals  $\Pi = \frac{1}{2} \varphi^2 \delta$ , where  $\delta$  = angle of torsion of the tube on application of unit moment.

V. K. Pereverzev

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3335. Hother-Lushington, S., and Johnson, D. C., The acceleration of a single degree of freedom system through its resonant frequency**, *J. Roy. Aero. Soc.* **62**, 574, 752-757 (Tech. Notes), Oct. 1958.

Using approximate methods based on simple physical and mathematical concepts, author solves subject problem for cases including damping. Comparison with exact theoretical solution shows excellent agreement.

B. Smilg, USA

**3336. Morley, L. S. D., The flexural vibrations of a cut thin ring**, *Quart. J. Mech. Appl. Math.* **11**, 4, 491-497, Nov. 1958.

Tabulations are given for the first ten modes of symmetrical and antisymmetrical vibrations. The rotatory inertia effects are neglected and the central line of the ring is assumed inextensible. The equations are solved rigorously.

J. F. Besseling, USA

**3337. Gravitz, S. I., An analytical procedure for orthogonalization of experimentally measured modes**, *J. Aero/Space Sci.* **25**, 11, 721-722 (Readers' Forum), Nov. 1958.

## Wave Motion and Impact in Solids

(See also Revs. 3239, 3270, 3374, 3680)

**3338. Mixson, J. S., The effect of beam loading on water impact loads and motions**, NASA Memo. 1-5-59L, 11 pp. + 4 tables + 11 figs., Feb. 1959.

An investigation of the effect of beam loading on impact loads and motions has been conducted in the Langley impact basin. Each of the impact-load and motion coefficients is found to be directly proportional to a power factor of the beam-loading coefficient  $C_{\Delta}$ ; for example, the maximum impact lift coefficient  $C_{L, \max}$  is found to be directly proportional to  $C_{\Delta}^{0.33}$  for 0° dead-rise models and to  $C_{\Delta}^{0.45}$  for 30° dead-rise models. An empirical equation for the prediction of  $C_{L, \max}$  is presented and shown to give generally good agreement with experimental  $C_{L, \max}$  for a large amount of data, including data obtained for beam-loading coefficients from 0.48 to 544.

From author's summary

**3339. Ivakin, B. N., Similarity in elastic wave phenomena, Part I** (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11, 1269-1281, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9358.

Author considers the establishment of similarity criteria for dynamic phenomena in an elastic body with discretely constant elastic coefficients and density (a laminarly elastic body). It is noted that various particular cases have already been treated by other writers [S. I. Tchubarova: "An investigation of the propagation of seismic waves by models," thesis, Moscow State University, 1954; M. V. Gzovsky: title source, no. 6, 527-545, 1954]. For each lamina, the Lamé differential equations are written and the boundary and initial conditions stated; and Hooke's law is developed for one lamina. Author next passes to the nondimensional quantities and by usual methods, in view of the third theorem of similarity [M. V. Kirpichev: "Theory of similarity," Moscow, Akad. Nauk SSSR, 1953], obtains a system of invariant equalities which are separated into two categories: Certain transformations are performed on the criteria obtained, and the final result is formulated; in like points of the full-scale case and the model, and at like time instants, on the condition of similarity of the initial displacements as well as the longitudinal and transverse velocities, the displacements and stresses will also be similar. The question of the similarity criterion for the case of harmonic oscillations is also examined.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3340. Ivakin, B. N., Similarity in elastic wave phenomena, Part II** (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1384-1388, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9359.

**3341. Vovk, A. E., Pasternak, R. N., and Tiutekin, V. V., Experimental investigation of the wave properties of a medium with cylindrical ducts, Soviet Phys.-Acoustics** 4, 1, 22-30, Oct. 1958. [Translation of *Akust. Zh.* 4, 1, 24-32, Jan./Mar. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.].

An experimental study is made of the wave properties of a rubbery material with cylindrical ducts. A method is given for computing the complex wave number from the measured magnitude of the complex impedance of a specimen of such a medium. Experimental results are given for various values of the duct radius. A comparison is made between experimental results and theoretical derivations.

M. Harrison, USA

**3342. Maier, K., Surge waves in compression springs, Prod. Engng.** 28, 8, 167-174, Aug. 1957.

**3343. Batterson, S. A., Investigation of the maximum spin-up coefficients of friction obtained during tests of a landing gear having a static-load rating of 20,000 pounds, NASA Memo.** 12-20-58L, 8 pp. + 1 table + 15 figs., Jan. 1959.

An experimental investigation was made at the Langley landing loads track to obtain data on the maximum wheel spin-up coefficients of friction developed during landing. The forward speeds ranged from 0 to approximately 180 fps and the sinking speeds, from 2.7 to 9.4 fps. The results indicated the variation of the maximum spin-up coefficient of friction with forward speed and vertical load.

From author's summary

**3344. Settles, J. C., Vibration and shock in freight cars as causes of lading damage, Trans. ASME** 80, 8, 1622-1628, Nov. 1958.

## Soil Mechanics: Fundamental

**Book—3345. First annual symposium on rock mechanics, Golden, Colo., Quart. Colo. School of Mines** 51, 3, July 1956, viii + 239 pp. \$2. (Paperbound)

This compilation reproduces papers and discussions from the first Annual Symposium on Rock Mechanics at the Colorado School of Mines. All problems are dealt with from the angle of mining engineering, as opposed to Talobre in his recent French treatise (same title) who approaches the subject as a hydro-power engineer and tunnel designer. Parts I and IV are on rock failure and rock fragmentation by blasting. Theoretical approach relating energy transfer to load is dealt with by C. W. Livingston. Obert, Noren and Kumao Hino report on test results on rock blasting. F. W. Brown writes on basic performance properties of blasting explosives. Theory of fracture is dealt with by H. Odé. Part II concerns design and support of underground openings. The research program of the School of Mining, Durham, England, is outlined by D. Banister. Stress redistribution on the periphery of openings is dealt with by J. J. Reed who describes models and laboratory tests. Poollen's contribution is on similar lines. Part III on mining by block caving is by Bucky and Hannifan.

C. Jaeger, England

**3346. Bolt, G. H., and Miller, R. D., Calculation of total and component potentials of water in soil, Trans. Amer. Geophys. Union** 39, 5, 917-928, Oct. 1958.

The total potential of water in moist soil is assumed to be the sum of gravitational, pressure, osmotic and adsorption components. Osmotic potential is related to solute concentration at any point. Adsorption potential is assumed to depend on interaction of water dipoles with electric fields associated with the solid-liquid interface. The Gouy-Chapman theory of the electric double layer provides a basis for computing both osmotic and adsorption potentials at any point in the liquid outside the first few mono-layers of water enveloping soil particles. From these, pressure potential can be calculated. Curves illustrating the variation of component potentials with distance from a particle are presented along with curves relating total potential to film thickness for soils brought to hydraulic equilibrium or to vapor equilibrium with external solutions. Measurement of total potential by freezing point depression is questioned.

From authors' summary by G. Sestini, Italy

**3347. Little, A. L., and Price, V. E., The use of an electronic computer for slope stability analysis, Géotechnique, Lond.** 8, 3, 113-121, Sept. 1958.

The application of an electronic computer to stability analyses of earth dams with pore-water pressure is described. The analyses are based on Bishop's (1955) adaptation of the Swedish method. The presentation of the data to the computer and its method of working are described and there is a brief discussion on the advantages of using the computer and possible future developments.

From authors' summary

## Soil Mechanics: Applied

(See also Rev. 3598)

**3348. Bechert, H., Calculation of annular foundations on elastic support (in German), Beton u. Stahlbeton.** 53, 6, 156-158, June 1958.

Author's exact solution of annular beam foundation assumes that the deformation of the ground is given by the coefficient of subgrade reaction. Various loads are taken into consideration (2 to 8 singular loads evenly distributed on a beam and four cases of antisymmetric loads). The loads are mathematically expressed in series and put into differential equations of deformations, at which the effect of torsion is also taken into consideration. Author simplifies the solution by suitable assumptions and provides an example in which a solution for a beam with radius of 6.5 m, loaded by three forces, is given. The final table shows that the differ-

ence between the bending moments of an annular beam and a straight one are negligible and that even in soft ground the torsional moment is given by an arm equal to only three hundredths of the radius.  
V. Mencí, Czechoslovakia

**3349. Bullen, F. R., Phenomena connected with the settlement of driven piles, *Géotechnique*, Lond. 8, 3, 121-134, Sept. 1958.**

Examination of many loading records has thrown light upon the frictional and toe values of the bearing capacity of a pile. The static toe values have been related to the elastic characteristics of the ground, and a connection found between these characteristics and the quake of the ground at the toe of the pile during driving.  
From author's summary

**3350. Tokar, R. A., The deformation analysis of foundations (in Russian), *Trudí N.-i. In-ta Osnovaniy i Fundamentov* no. 30, 5-38, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9475.**

The calculation of foundations by the method of assumed limiting conditions is discussed. The calculation must satisfy the requirement  $s < f$ , where  $s$  is the anticipated deformation of the foundation, and  $f$ , the amount of deformation of the foundation permissible from considerations of the strength and occupation of the building structure. Foundation deformations are classified into three forms: uniform subsidence, tilting, and relative bending. Depending on the type and purpose of a building, different requirements are to be applied to the limiting values of these three forms of deformation, in order to insure suitability in occupation and structural strength of the building. Data on subsidence and deformation for 74 buildings and structures are analyzed, classified according to the type of structure. The extent of deformation of any kind leading to loss of structural strength is investigated. There appears to be, from empirical data, a linear relationship between the relative bending (sag) and the mean subsidence, and author attempts to establish possible values for the coefficients of proportionality in this relationship, depending on the rigidity of the structure. The possible influence on the rigidity of spans is investigated.

As a result of his researches, author suggests a draft of standards for subsidence and differential subsidence in building structures depending on the purpose, type of foundation, and nature of the soil. This draft has been incorporated in the current "Standards and Technical Conditions for the Design of Natural Foundations for Buildings and Industrial Structures" (NiTU 127-55).

M. I. Gorbunov-Posadov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

## Processing of Metals and Other Materials

(See also Revs. 3265, 3331, 3332, 3393, 3394, 3700)

**3351. Cook, N. H., Self-excited vibrations in metal cutting, *Trans. ASME 81 B(J. Engng. Indust.)* no. 2, 183-186, May 1959.**

The basic mechanisms which cause self-excited vibrations on a cutting tool relative to the work are discussed in a qualitative manner. Similarly, mechanisms inherent in the cutting process which can damp or limit vibrations are discussed. Experiments are presented which are in agreement with the theory.

From author's summary

**3352. Voronov, A. L., Quality of surfaces machined by cutting tools with vibration-damping faces (in Russian), *Vestnik Mash.* 36, 6, 30-33, June 1956.**

**3353. Kravchenko, B. A., Theoretical determination of a cutting force (in Russian), *Vest. Mashinostroyeniya* no. 12, 44-48, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12001.**

On the basis of the assumption that cutting is a process of a single-axis plastic compression, a variant was obtained of the simplified expression for the cutting force, and this was compared with the experimental results.

G. S. Shapiro

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3354. Chetkin, P. P., Investigation of the shrinkage of plates made of leathery plastics during the milling process (in Russian), *Nauch. Trudí Mosk. Tekhnol. In-ta Legkoi Prom-sti* 7, 100-107, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12287.**

Experimental data are produced regarding the deformation of plates, made of leathery plastics, during the milling process; an experimental relation is derived between the elongation and the degree of shrinkage; the possibility is discussed regarding improvement of the existing technological process of milling.

V. A. Lomakin

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3355. Beck, G., The effect of heat on tool steels during hot upsetting and forging in swages (in German), *Stahl u. Eisen* 78, 22, 1556-1563, Oct. 1958.**

Reasons for the determination of the chronological and local temperature field in swages are presented. Arrangement of the measuring apparatus and factors of influence are described. Test results are given. Calculations are made of temperature field and of different characteristic data for the transfer of heat by using the temperature as measured.  
From author's summary

**3356. Artobolevskii, I. I., Mechanism of rounding-off conical-section drawing instruments (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* 104, 5, 702-705, Oct. 1955.**

**3357. von Hofsten, C.-O., and Lindstrand, E., Experimental research on wire drawing (in Swedish), *Jernkontorets Ann.* 142, 3, 128-164, 1958.**

Experiments were performed on a wire-drawing machine for dry drawing, having a speed range from 90 to 1000 fpm. Drawing force and die temperature were measured. Main part of the investigation deals with the influence of different coatings on drawing force and temperature. Optimum die angle and properties of a rotating die were also studied.

In drawing annealed wire of low and medium carbon content, lowest temperatures were obtained when using sullcoat in combination with borax. Even in other types of drawing experiments this combination gave good results, which does not quite agree with experience from wire-drawing plants.

Experiments with different die angles showed that an angle of about 14° was most favorable, which was expected from earlier investigations.

Rotation of the die appeared to have no influence on the drawing force as long as ratio between speed of rotation and speed of drawing was kept within practical limits.

From authors' summary by A. Isaksson, Sweden

**3358. Petrik, M., Contribution to the theory and design of pneumatic extensometers (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; 8, 421-429.**

## Fracture (Including Fatigue)

(See also Revs. 3344, 3380, 3577)

**3359. Alekseichenko, A. V., Investigation of the process of crack development in the tension zone of ferro concrete bridge beams when being deflected by a transverse force** (in Russian), *Trudt Vses. N.-i. In-ta Transp. Str.-va* no. 19, 177-250, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12121.

Experimental data are furnished to show the regularity of the developments of diagonal cracks in ferroconcrete beams by forces perpendicular to their axis. The development of diagonal cracks is influenced by the same factors met with in the development of vertical cracks on a portion of the distributed longitudinal reinforcement. The influence of the following factors in the development of diagonal cracks was established experimentally: the diameter of the reinforcement, the coefficient of reinforcement of the section with hooked rods and bands, the density of the concrete, the reinforcement stresses, the character of the action exercised by the load (repeated once or many times). The ordinary method for the determination of the thickness of the wall of a ferroconcrete beam on the basis of calculation of the principal tension stresses in the concrete is disputed. As an alternative, the proposal is put forward to ascertain the thickness of the wall by taking in hand calculations for the opening of the cracks and for the principal compressive stresses. A formula is given for the determination of the maximum opening up of the cracks having in view the containing of this opening within the limits of harmless values of the order of 0.3 mm. Auxiliary opening up of the cracks as the result of the action of secondary loading reaches 40-50% of the size of the opening up at the original loading.

K. S. Zavriev

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3360. Lebedev, A. S., Life of components with metallic coatings** (in Russian), *Trudt Leningr. Inzh.-Ekon. In-ta* no. 13, 69-85, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12190.

Coatings are examined, obtained by welding, metallization, chrome-plating, electro-iron deposition and deposition by electric arc treatment. The 'life' is determined by endurance stability and fatigue resistance. Comparative data are given indicating the influence of the coatings on the fatigue of steel components. It is to be noted that all forms of coatings cause a lowering of fatigue resistance. A particularly unfavourable influence is exercised by the preparation of the surface to be metallized by first roughening it (the endurance limit is 49% less than in the original metal). In order to increase the endurance limit of hardened and non-case-hardened cylindrical components it is expedient to carry out the preparation for metallization by milling, but for components with hard surfaces by electro-arc treatment. The most effective for endurance stability under wear conditions in combination with Babbitt metal, with bronze and cast iron, appears to be porous and smooth chrome; next in order comes metallization, then welding on, and, finally, steel hardening. Data are presented regarding the endurance stability of coatings relative to the thickness of the coverings. Endurance stability is determined by means of wear, testing the covering with a disk made of a hard alloy. It is also to be noted that smooth chrome can expediently be employed for covering components working under high specific pressure. Steel metallization coverings can be expediently utilized when a component is working at low speeds of slip and small pressures, in conditions of viscous friction; electro-arc deposition can be effectively used for components working in moving articulations; steel hardening can be usefully employed for components working in immovable settings. For components with movable settings

steel hardening is recommended, followed by subsequent chrome or cementation treatment.

V. K. Pereverzev

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3361. Glen, J., Ductility in high-temperature rupture tests**, *J. Iron Steel Inst. Lond.* **190**, 1, 30-39, Sept. 1958.

In previous work, author has shown strain-age hardening and associated loss in ductility in tensile tests at elevated temperatures. Similar effects occur during creep test, causing "transitions" in the creep rate. From extensive experimental studies, author reports that fracture in long-duration creep-to-rupture tests may result from two mechanisms: a "normal" mechanism and an embrittling mechanism. Fracture by the latter mechanism is associated with a transition in creep rate, and hence with strain-age hardening.

G. V. Smith, USA

**3362. Clarke, J. S. and Leahey, T. F., Storage-tank design practices to avoid brittle fracture**, *ASME Ann. Meet.*, New York, N. Y., Nov./Dec. 1958. Pap. 58-A-149, 8 pp.

**3363. Uzhik, G. V., Resistance limit of plastic metals to brittle breaking** (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles 1957; **8**, 299-311.

**3364. Charles, R. J., Dynamic fatigue of glass**, *J. Appl. Phys.* **29**, 12, 1657-1662, Dec. 1958.

An analytical model, which is applicable to static fatigue of lime glass, has been extended to account for dynamic fatigue of the same glass. The model successfully predicts the room temperature strain rate sensitivity of the failure process in lime glass and indicates a method by which the stress-concentration relationship, applicable to microscopic flaws on glass surfaces, may be obtained by experiment. Resulting experiments showed that the stress-concentration relationship proposed by Inglis is valid.

From author's summary

**3365. Baughman, R. A., Experimental laboratory studies of bearing fatigue**, *ASME Ann. Meet.*, New York, N. Y., Nov./Dec. 1958. Pap. 58-A-235, 8 pp.

**3366. Dischka, G., and Hajmasy, T., The determination of the fatigue characteristics on fabrics with alternate loads in the higher range of frequencies** (in German), *Faserforsch. u. Textiltech.* **9**, 7, 286-297, July 1958.

A vibrations endurance test machine, developed by the Hungarian research institute for the textile industry, is described and the equations of motion are given on which its construction is based and from which, as indices for the examined fabric, the modulus of elasticity  $E$  and the coefficient of viscosity  $\eta$  are derived. Finally, the results of three series of tests with fabrics of different types of bindings (kasha, velour, cloth) and of different fiber mixtures (shorn wool, reclaimed wool, staple fiber, Grilon) are given.

From authors' summary

**3367. Mamontov, E. A., X-ray diffraction investigation of fatigue in steels** (in Russian), *Uch. Zap. Leningr. Gos. Ped. In-ta* **125**, 31-48, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12249.

Results are given of the roentgenray investigations made on steels U-10 and steel 30 in fatigue. The author comes to the conclusion that the development of second-order stresses depends on the form of the material and can differ in accordance with the properties of this material. He admits that a build-up of stresses of the third order does not by itself produce conditions for fatigue fracture. The author is of the opinion that there is confirmation for the possible evaluation of the limit of fatigue, based on the

sharp fall in the intensity of the interference lines (Terminasov's criteria of fatigue).

I. V. Vikker

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3368. Gol'tsev, D. I., Relative distribution of fatigue curves for cyclically worked material** (in Russian), Questions in dynamics and dynamic stability, no. 4, Riga, Akad. Nauk LatvSSR 1956, 73-85; Ref. Zh. Mekh. no. 10, 1957, Rev. 12247.

An evaluation is made of the overloading effect based on the energy dissipation during cyclical loading. The general energy of dissipation is investigated as the sums of its 'safe' and 'dangerous' parts. The 'safe' component is calculated for the stress equal to fatigue limit, and to the corresponding number of cycles of loading. The 'dangerous' part is taken to be a constant for the material. In consequence, the higher the level of the overloading reaction, the smaller will be the number of cycles needed for the full expenditure of its possible reserves. It is assumed that in the preliminary overloading reaction the unexpended reserve differs from the difference between the full reserve of 'dangerous' energy per unit of volume and its absorbed portion, because the manipulation effects a change in the properties of the metal, among others the magnitude of the 'dangerous' energy. On this basis a balance is arrived at of the energy consumption of the dissipation and a formula is obtained for the calculation of the secondary limit of fatigue. An evaluation is also possible of the steepness of the left parts of the curves for secondary fatigue.

M. Ya. Shashin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3369. Bogdanoff, J. L., and Goldberg, J. E., A new analytical approach to drill pipe breakage**, ASME Petrol.-Mech. Engrg. Conf., Denver, Colo., Sept. 1958. Pap. 58-PET-12, 22 pp.

Drill pipe dynamics are attacked analytically, using the statistical approach. The study concerns itself with shear and normal stress in a drill pipe, driven at one end in a fairly uniform manner but subjected at the other end to random torque and axial conditions. Both a Gaussian distribution and the maximum shear theory of failure are assumed.

Formulas describing the probability of stresses exceeding a given level are derived. Indications are that the torsional and axial stiffness of the pipe can be controlled to reduce the probability of exceeding a stress to a minimum. It is furthermore shown that there exist stiffness values for which the maximum shearing stress variance is a minimum. Lack of corroborating experimental data at this time does not permit authors to claim any finality for the method. Should difficulties exist, deficiencies could be remedied after basic experimentation provides necessary parameters and proper idealized drill rig models.

J. P. Vidosic, USA

## Experimental Stress Analysis

(See also Revs. 3254, 3367)

**Book—3370. Durelli, A. J., Phillips, E. A., and Tsao, C. H., Introduction to the theoretical and experimental analysis of stress and strain**, New York, McGraw-Hill Book Co., 1958, xxx + 498 pp. \$12.50.

This book is likely to find its way to the bookshelf of any serious student of stress analysis. It performs a useful service in constantly stressing the actual physical limitations involved in applying the mathematical theory of elasticity. Photoelastic models are used wherever applicable, but the book is particularly outstanding in the treatment given to stress coat. Not only are the techniques discussed in great detail, but also their application

to problems in stress analysis. Since there are so many other books on the subject of resistance strain gages and so few that cover brittle coating methods, the concentrated attention to the latter to the virtual exclusion of the former represents no handicap.

The book is in five parts. The first covers mathematical analysis of stress and strain, with emphasis on three-dimensional treatment. The second covers the fundamental concept of strain measurements and their interpretation. The third section discusses grid methods; the fourth, brittle coating methods for strain analysis. The book concludes with a brief section on mechanical strain gages.

E. G. Loewen, USA

**Book—3371. Coker, E. G., and Filon, L. N. G., A treatise on photo-elasticity**, 2nd ed., New York, Cambridge University Press, 1957, xii + 720 pp. \$12.50.

A new edition of this now classic treatise some 25 years after its first appearance in 1931 is most certainly to be welcomed, for it contains the most comprehensive exposition available of the theory of photoelasticity and the principles of its application. These fundamentals are essential to a complete understanding of two- and three-dimensional photoelasticity and the more recent techniques of photoplasticity, dynamic photoelasticity and photo-thermoelasticity.

H. T. Jessop, who has undertaken the preparation of this second edition (in addition to revitalizing and modernizing Coker's laboratory), has exhibited remarkable restraint in retaining substantially the original form of the book. The essentially timeless elements of theory are thus preserved together with the now historically interesting experimental and modelling techniques. Not that all of the experimental aspects are dated, for some of the investigations of the behavior of various cutting tools upon a workpiece are of remarkable lucidity and retain their interest today. Professor Jessop has provided an interesting reviser's introduction, essentially historical in nature, which reviews the significant developments in photoelasticity during the past 25 years. Appended is a rather complete bibliography of almost 100 publications up to 1955.

The great interest in the earlier edition has made it a much sought after prize in the out-of-print market. The new edition will most happily serve the interests of the current generation of photo-elasticians. In fulfilling this need, Cambridge University Press is indeed to be congratulated.

G. Gerard, USA

**3372. Loist, K., and Weber, J., Photo-elastic investigation of rotating disks with eccentric holes** (in German), *Dtsch. Versuchsanstalt Luftfahrt Rep.* 57, 60 pp., Apr. 1958.

At eccentrically placed holes in rotating disks there will be stress concentrations, whose magnitude depends on hole diameter, number of holes, and place of holes. Authors investigate experimentally the influence of number and size of holes in model disks with constant thickness. Influence of place of holes is investigated theoretically only, as this question should be considered in connection with radial variation of disk thickness, which determines radial and tangential stresses due to centrifugal forces.

Models have outer diameter 300 mm, shaft hole 40 mm. First is studied disk without eccentric holes in order to get correlation values. Stresses are rotational symmetric and no special arrangements were necessary to get stress pattern. Sodium light was used. Different prestresses between shaft and disk were also studied. Then is studied influence of two diametrically placed holes, 180 mm apart, hole diameters varying from 15 to 30 mm. A Philip stroboscope is used as light, giving from 0.5 to 250 lights per sec. Duration of each light could be varied between 10 and 30 microsec, giving a spread of 1 to 3 mm at outer disk diameter. Red filter is used. Intermitent light seems to be a very useful tool. Influence of number of holes is studied for 2, 4, 8, 12, 16, and 17

eccentric holes, placed on a diameter 180 mm; hole diameter 30 mm. Results are compared with theoretic values.

For dimensions used, stress concentration for two holes is greatest at outer radial border of holes and greater than theoretical value. Hole diameter has slight, if any, effect on concentration factor. As number of holes increases, stress in material between adjacent holes also increases, and decreases stress at radial borders of holes. For 10 or 11 holes the biggest principal stress is nearly constant around the holes.

An interesting paper.

E. R. Steneroth, Sweden

**3373. Newton, C. J., False negative permanent strains observed with resistance wire strain gages, *ASTM Bull.* no. 235, 42-44, Jan. 1959.**

In connection with a project that involved the determination of the elastic limit of specimens of steel by means of electrical resistance strain gages, it was observed that below the yield point the resistance gages often indicated strains upon release of the load that were oppositely directed to the preceding load. Comparison with permanent strains observed with optical gages on the same specimen showed that in this case the negative strain was a false indication of the resistance gage.

From author's summary

**3374. Durelli, A. J., Dally, J. W., and Riley, W. F., Developments in the application of the grid method to dynamic problems, AFOSR TN 58-893 (Armour Res. Found., Ill. Inst. Technol.; ASTIA AD 204 136), 14 pp. + 12 figs., Dec. 1958.**

The objective of the research reported in this paper was to further develop the grid method for use in dynamic stress studies. A rubber-thread grid network in a low modulus model material (a urethane rubber known as Hysol 8705) was used in conjunction with a microflash light source to record grid distortions and photoelastic fringe patterns in a model subjected to dynamic loading conditions.

By considering a strut subjected to axial impact it was possible to establish that the static and dynamic values of Poisson's ratio were identical, and the strain fringe value of the material varied with strain rate. In addition, stresses in the axial and transverse directions were determined along the centerline of the strut. Finally, the methods established were applied to the problem of a circular disk subjected to diametrical impact and both principal stresses were determined along a vertical diameter at one instant during impact.

From authors' summary

**3375. Stein, P. K., A simplified method of obtaining principal stress information from strain gage rosettes, *Proc. Soc. Exp. Stress Anal.* 15, 2, 21-38, 1958.**

Author shows how the characteristics of a Wheatstone bridge and strain-gage rosettes can be used in a relatively simple manner to reduce substantially the computations involved in the rosette problem. Ordinary measuring instruments such as the Baldwin Type L or M strain indicator can be used. The circuits required are discussed and the basic theory is clearly presented. Nonelectronically inclined stress analysts, if there are any left, should have no difficulty in understanding and using the methods described.

E. A. Ripberger, USA

**3376. Gasanov, A. G., Question of investigating the stresses appearing in a motor-car chassis (in Azerb.), *Trudf Azerb. Industr. In-ta* no. 15, 145-156, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12183.**

The data gathered in the experimental investigation of the stressed state of the chassis of a lorry, Type EIS-150, in differing work conditions are put forward. A detailed description is given of the electroensometer apparatus disposed in the body of the lorry. The methods used in carrying out road tests are given. Particularly detailed study was devoted to the most characteristic sections in which, ordinarily, fracture of the chassis took place. An

analysis is furnished of the test results and recommendations are made for improvements of construction.

N. P. Kashparova

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3377. Maltsev, P. A., A deformation meter for measuring residual and total stresses (in Russian), *Trudf Mosk. In-ta Inzh. Zb.-d. Transp.* no. 85/6, 42-49, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9813.**

A deformation meter has been designed and developed [cf. G. K. Yevgrafov, P. V. Maltsev, V. O. Ossipov, *Trudf Moscow In-ta Inzh. Zb.-d. Transp.* no. 85/86, p. 5-28] for the experimental determination of residual and total stresses by the drilling method. The instrument is intended to measure deformations resulting from the combined action of residual and total stresses, as well as each of these stress forms separately. The deformations are measured simultaneously along three radii round a hole of 6-12-mm diameter.

The indications of the instrument are recorded before starting drilling and further, in order to check the working of the instrument, after every 1-2 mm advance of the drill, as well as on completion of drilling. Only the initial and final records are used in evaluating the results. In thick metal, drilling is continued to such a depth that the difference between the instrument readings ceases to increase.

A. Ya. Brodskii

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3378. Georgiyevsky, M. B., Cheredov, S. V., and Medvinsky, M. D., A multi-channel measuring device for working with resistance-wire strain gages (in Russian), *Experimental Methods in Research on Machines*, Moscow, Izd-vo Akad. Nauk SSSR, 1954, 28-69; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9816.**

A description and particulars of a three-channel measuring amplifier for working with resistance-wire strain gages (PET-3-B). The instrument is fed from a stabilized rectifier and gives steady readings with supply voltage fluctuations between 19-230 volts, as well as having a rectilinear frequency characteristic between 0-1600 c/s, with an output current of 100 milliamps. The circuits for connecting the resistance bridges and gages, given in the paper, have been published repeatedly.

V. N. Maksimov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

## Material Test Techniques

(See also Revs. 3397, 3424)

**3379. Kubasov, V. A., and Popov, Yu. I., The use of the ordinary wire torsional test machine for the hot-testing of steel samples in torsion (in Russian), *Zavod. Lab.* 22, 11, 1365-1367, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9777.**

Modifications made in the construction of the K-2 testing machine, relating to the kinematic arrangement, are described; the samples are heated in a steel muffle in an electric furnace.

The characteristics of the modified machine are as follows: The torsional moment with 7.8-kg test load is 300 kgcm; the maximum number of full revolutions which can be plotted on the chart is 4; furnace temperature up to 1100°; test piece diameter, 6 mm. Charts are reproduced for samples of St. 3 steel at  $t = 20$  to 500°.

M. R. Shamilev

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3380. Sveshnikov, D. A., and Maslennikov, G. A., A machine for fatigue-testing coiled cylindrical springs and wire (in Russian),**

Zavod. Lab. 22, 10, 1245-1247, 1956; Ref. Zh. Mekh. no. 8, 1957, Rev. 9765.

The construction is described of a machine for fatigue-testing coil springs. The alternating loads are produced by rotating the spring, while bent through a circular arc. The stresses in the spring vary in a symmetrical cycle. The requisite amplitude of the alternating stress is obtained by bending the axis of the spring to a given curvature. The machine enables destructive testing, even of such springs as do not fail under alternating compression to clashing of the turns. The focus of the fatigue failure in testing springs by this machine arises not in the inner fibers of the turns (as in the case of springs working under axial load), but in the lateral fibers. A machine of similar construction can be used for fatigue-testing wires.

N. I. Popov

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

3381. Filippi, F. J., Qualitative analysis of brazed sandwich, *Nondestructive Testing* 17, 1, 39-45, Jan.-Feb. 1959.

3382. Hawkes, P. E., and Ek, C. H., A machine for evaluation of high-temperature alloys under combined static and dynamic stresses, *ASTM Bull.* no. 235, 46-51, Jan. 1959.

A resonance type of testing machine has been developed to serve as an aid in the development of new high-temperature alloys. The machine subjects the specimen to a static or stress-rupture loading combined with a high-frequency fluctuating stress, to simulate service loadings typical of highly stressed components such as gas turbine buckets, wheel materials, combustion chamber liners, and the like. The test temperature range is from 1000 to 1800 F.

The static (axial) component of stress is obtained through the use of a lever and dead weight system, while the dynamic stress results from lateral resonant vibration of the vibrating system composed of the specimen itself together with the axial loading device clucked to its upper end. The machine is equipped with two servo systems for automatic control of amplitude of lateral vibration and of temperature at the test section.

A digital program which calculates the stresses and vibratory elastic line of a 12-section axially loaded beam is employed as a convenience in obtaining a stress calibration for the machine under a variety of combined loadings, materials, and temperature distributions.

Results of tests on two high-temperature alloys, A286 and GMR235D, are included to illustrate the utility of the machine. Data are presented as modified Goodman-type diagrams as well as three-dimensional diagrams incorporating axes of static loading, dynamic loading, and time.

From authors' summary

3383. Hersch, P., Routine apparatus for determining the surface area of metal powders, *J. Inst. Metals* 86, 12, 509-511, 1957/58.

Routine experimental procedure to measure surface areas of metal powders is described. Emmett's "one-point" variation of the BET method is used. The apparatus requires no dead-space measurement; only one point on the adsorption isotherm is needed. Five to six surface area determinations can be made per day by a single operator. Results are reproducible within  $\pm 5\%$ .

S. R. Faris, USA

3384. Fridman, Ya. B., Some results from the study of the characteristics of the destruction of materials (in Russian), *Modern methods of taking materials in machine construction*, Moscow, Mashgiz, 1956, 5-38; Ref. Zh. Mekh. no. 10, 1957, Rev. 12212.

A review of the work of the author and other investigators on the conditions of work of materials at the destruction stage. The questions are examined in regard to the influence of time, the local and averaged evaluation of the mechanical properties of the materials, the consideration of the anisotropy of the materials, their

sensitivity to cuts, defects and cracks and evaluation of the fatigue resistance when subjected to nonuniform sequences of loading. It was indicated that notwithstanding the widely-held view, the appearance of creep is possible in constructional steels, and also of slow deterioration even at room temperature. A description is given of the diagram put forward by the author for the relative structural heterogeneity, the existence of which merges with the study of the correlations between the dimensions of the zone with maximum stresses and the dimensions of the structural heterogeneities. The unusual mechanical properties of plastics is noted, as these have to be taken into account in calculations for these materials.

Yu. I. Yagn and Yu. A. Sozonov

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

3385. Potenski, A. R., Radiographic inspection of welded turbine wheels for jet starters, *Nondestructive Testing* 17, 1, 29-31, Jan.-Feb. 1959.

Paper covers the details of the radiographic inspection procedure and evolved standards used for welding evaluation of the turbine wheels for jet starters.

From author's summary

3386. Polansky, D., Case, D. P., and Criscuolo, E. L., The investigation of radioisotopes for the inspection of ship welds, *Nondestructive Testing* 17, 1, 21-25, Jan.-Feb. 1959.

A study was made of the feasibility of using isotopes for the inspection of welds in ship structures. Technique and sensitivity curves for thulium, iridium, cesium and cobalt are included. For the inspection of welds in  $\frac{1}{2}$ -inch to 1-inch plate, iridium is the most promising isotope. A portable exposure container for iridium has been developed.

From authors' summary

3387. Bobbin, J. E., Ultrasonic weld inspection, *Nondestructive Testing* 17, 1, 26-28, Jan.-Feb. 1959.

## Properties of Engineering Materials

(See also Revs. 3253, 3254, 3256, 3259, 3260, 3262, 3364, 3366, 3404, 3426, 3657)

Book—3388. Kollbrunner, C. F., *Modern steel construction* [*Neuzeitlicher Stahlhochbau*], no. 22, Zurich, Verlag Leemann, 1957, 56 pp. (Paperbound).

The well-illustrated booklet briefly outlines the advantages of steel in building construction and briefly describes applications to large welded portal frames and multistorey building frames in various countries. Results of tests on behavior of steel at high temperatures and under axial buckling stresses are also summarized. Bibliography of author's previous publications in field is appended.

G. G. Meyerhof, Canada

3389. Bungardt, K., and Mulders, O., Mechanical properties at elevated temperatures of hot-working steels suitable to quenching and subsequent drawing (in German), *Stahl u. Eisen* 78, 16, 119-126, Aug. 1958.

Paper states effect of the tempering temperature ( $T$  in  $^{\circ}\text{K}$ ) and of the tempering time ( $t$  in hrs) and of the tempering parameter ( $P = T [19 + \log t]$ ), respectively, upon the tensile strength, the 0.2% elongation, the ratio of yield point to the tensile strength, the reduction in area at rupture, and the breaking elongation of steel types X 30 WCrV 9 3, X 30 WCrV 5 3, X 30 WCrV 4 1, 45 CrVMoV 5 8, 45 CrMoV 6 7 and X 38 CrMoV 5 1 at temperatures up to 700 C. Authors state conclusions to be drawn for the selection of the steel.

From authors' summary

3390. Smith, C. R., Thin doublers for fatigue-resistant aluminum-alloy structures, *Aero/Space Engng.* 18, 2, 40-43, Feb. 1959.

A description of how high bending stresses can be reduced by thin doublers of titanium or stainless steel engaging an extra row of rivets outside the main splice. While this introduces a problem in bimetallic corrosion, the gains in fatigue life and fail-safe features more than offset the extra work required for corrosion prevention.  
From author's summary

**3391. Inglis, N. P., and Larke, E. C., Strength at elevated temperatures of aluminum and certain aluminum alloys, Instn. Mech. Engrs., Prepr., 11 pp., 1958.**

**3392. Gerard, G., An evaluation of structural sheet materials in missile applications, Jet Propulsion 28, 8, 511-520, Aug. 1958.**

**3393. Danilova, G. P., Kamenskaya, E. A., and Mal'tsev, M. V., Modification of the carbide phase in titanium alloys (in Russian), Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk no. 2, 150-152, Feb. 1957.**  
Effect of Mo, W, V, Zr, Nb, Ta, and B on the coarse carbides in microstructure of titanium melted in graphite was studied. Additions of boron and/or Mo and other elements give finer carbide (or boride) was-cast structure. Authors claim process is analogous to modification of Al-Si alloys and increases nucleation of solid carbides. Improvement of 40-60% in impact strength and workability is noted.  
R. W. Guard, USA

**3394. Gudtsov, N. T., and Panchenko, I. P., Titanium alloys with wolfram and aluminum (in Russian), Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk no. 2, 139-143, Feb. 1957.**

Authors measured the hardness, rupture strength and oxidation resistance of Ti-3Al Alloys with 5, 10, 15 W added. Quench specimens hardened on exposure by transformation of  $\beta$  to  $\alpha$  and precipitation of W rich phase. Carbides are relatively uninfluenced by aging. Rupture strength increases with increase of wolfram, while oxidation resistance is optimum at 5% level. Observations and properties are similar to commercial 3Al-Mo and 5 Al-Mo alloys of U. S.  
R. W. Guard, USA

**3395. Kerper, M. J., Mong, L. E., Stiefel, M. B., and Holley, S. F., Evaluation of tensile, compressive, torsional, transverse and impact tests and correlations of results for brittle cermets, J. Res., Nat. Bur. Stands. 61, 3, 149-169, Sept. 1958.**

Static tests were studied for the determination of mechanical properties of brittle materials. Specimens of brittle materials, represented by cermets having five different compositions, were subjected to tensile, compressive, torsional, transverse, and impact tests. The designs of specimens and apparatus, suitability of the tests to the materials, refinements in test procedures, and the variability of results and their correlation were studied. The elastic properties were obtained from tensile, compressive, and transverse tests, and the modulus of rigidity calculated from the results of these tests agreed with that from the torsional test. Tensile strength was obtained from the tensile, torsional, and transverse tests on specimens of comparable sizes in accordance with a limiting tensile strain. Shear strengths were obtained in the compressive tests. The correlation of impact values with mechanical properties was unsatisfactory.

From authors' summary

**3396. Deutsch, G. C., Meyer, A. J., Jr., and Ault, G. M., A review of the development of cermets, AGARD Rep. 185, 11 pp. + 4 tables + 12 figs., Mar.-Apr. 1958.**

Cermet materials are defined and the development of different varieties of cermets is discussed. The physical and mechanical properties of cermets are dealt with, special reference being given to the normally poor impact strength and ductility of these materials. Possible ways are considered in which these two properties might be improved.  
From authors' summary

**3397. Thal, K. E., The deformation of concrete in compression (in Russian), Investigations on the strength, plasticity and creep of building materials, Moscow, 1955, 202-207; Ref. Zh. Mekh. no. 8, 1957, Rev. 9780.**

The results of tests in axial compression are communicated, made on prisms of reinforced and nonreinforced concrete. The concrete had a crushing strength of 105 kg/cm<sup>2</sup> (prism test) while the reinforcement was of cold-drawn wire with a nominal yield point in compression of 5000 kg/cm<sup>2</sup>.

The values of the mean limiting strain were, for the nonreinforced prisms,  $\sim 2 \times 10^{-3}$ , and for the reinforced prisms, twice that, i.e.  $\sim 4 \times 10^{-3}$ . Stress curves for the concrete and the reinforcement are given; the stresses in the concrete of the reinforced prisms reached a maximum at a deformation of  $\sim 1.2 \times 10^{-3}$  and a load of 80% of the maximum. With further increase of the load, the stress in the concrete decreased, because of redistribution of the load to the reinforcement, while the deformation value abruptly increased.

Owing to technical difficulties, it has proved impossible to observe directly during the test, the phenomenon of appreciable growth of the plastic deformations in compressed concrete, accompanied by decreasing compression stresses.

A. E. Desov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3398. Marin, J., and Sharma, M. G., Material rating based upon true stress-strain properties, Welding J. 37, 8, 375-s-378-s, Aug. 1958.**

**3399. Sippel, A., The dependence of the tensile strength of a filament on its length between the jaws. I. Theoretical part (in German), Faserforsch. u. Textiltech. 9, 5, 163-167, May 1958.**

**3400. Osherovich, L. I., The influence of moisture on the value of the limit of stability and on the modulus of elasticity when the timber is in tension across the grain (in Russian), Sb. Nauch. Rabot. Belorus. Politekh. In-ta no. 54, 167-172, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 12280.**

Descriptions are given of the tests on samples of pine wood with different moisture contents; the test samples had a working length of 40 mm with constant transverse section of  $10 \times 30$  mm with cross rounding off of the end parts. The question is examined of the correction coefficients for moisture.

Yu. M. Ivanov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3401. Saarman, E., Strength of screws in wood and wooden products (in Swedish), Sven. TraforskInst. Medd. 96 B, 7 pp., 1958**

## Structures: Simple

(See also Revs. 3200, 3230, 3254, 3273, 3274, 3275, 3302, 3312, 3321, 3388)

**3402. Hodge, P. G., Jr., The practical significance of limit analysis, J. Aero/Space Sci. 25, 11, 724-725 (Readers' Forum), Nov. 1958.**

In this short article two examples show that "the limit load which has a precise meaning for the perfectly plastic material has qualitative significance for more realistic materials. Below the limit load, the deformation increase associated with a given load increment is of the same order of magnitude as in elasticity, whereas above the limit load it is greater by a factor of ten or more."

From author's summary by A. J. Bignoli, Argentina

**3403. Pozzati, P., Net of beams** (in Italian), *G. Gen. Civ.* **96**, 1, 32-47, Jan. 1958.

Author applies finite difference method to obtain a solution for the deflections of a set of beams which intersect at right angles. Equations are written for the deflection of each joint, assuming deflections perpendicular to the plane of the net only. Torsional resistance of the beams is also considered. Three simple net problems are solved.

A rigorous solution of the net problem is very complicated. The approximate method described provides a satisfactory solution under certain conditions, and is reasonably simple.

C. Papaioannou, Greece

**3404. Nesovic, B., New method of manufacturing reinforced concrete pipes** (in Serbian), *Naše Građevinarstvo* **12**, 10, 224-228, Oct. 1958.

Importance of pressure pipes is discussed and the advantages and disadvantages of both materials, metal and reinforced concrete, are thoroughly described, on the basis of many tests. Author suggests various improvements, especially lining with hard polyvinyl, steel sheets and asbestos-cement.

J. J. Polivka, USA

**3405. Bouteloup, P., Dome and non-reinforced arches** (in French), *Ann. Ponts Chaus.* **128**, 4, 429-505, July-Aug. 1958.

Domes, one of the oldest methods of roofing in the history of humanity, call for very little calculation or study if they have only a small span. If their span is considerable, their stability and the economy of their construction call for very careful attention. A good deal of research has already been done along these lines, but in connection with existing domes of which the structure was causing anxiety.

Paper gives a systematic analysis of the stability of domes and deduces the elementary rules to be followed. His studies have led the writer to examine in greater detail a few special types of domes suitable for use in architectural designs. Author deals here with masonry domes without metal framework, but brings out the advisability in certain cases of using hoops, for which he gives the calculation. Some of the rules he lays down could thus be applied to other structural methods.

From author's summary

**3406. Wansleben, E. H. F., Investigation of a reinforced horizontal supporting container ring** (in German), *Stahlbau* **26**, 4, 103-107, Apr. 1957.

**3407. Shkerbelis, K. K., Calculations for redundant ferroconcrete structures with constant loads acting for prolonged periods** (in Russian), *Investigations on concrete and ferroconcrete*, no. 1, Riga, Akad. Nauk LatvSSR, 1956, 77-93; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12132.

An investigation is carried out on a simplified method of evaluating the variations in size of redundant unknowns. By using the method of forces the coefficients of the canonical equations are calculated, taking into account the creep of the concrete. On this basis an equation for the three moments is derived and an examination is made of the calculations for a continuous beam and a simple frame. Experiments are described which had as their object the establishment of the values of the momentary and prolonged moduli of elasticity, and also the relaxation time. In connection with the above a criticism is given of Naud TU 123-55.

N. P. Kashparova

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3408. Rudashevskii, I. G., Some cases of calculations for compressed-bent rods** (in Russian), *Trud Leningr. In-ta Inzh. Vod. Transp.* no. 23, 91-100, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12081.

In four cases of longitudinally transverse bending of girders of constant section, fastened at one end, and, in addition to an evenly-distributed longitudinal load, under the action of a different transverse load as well, expressions are found for the deflection moment, for the deflections and for the angles of rotation of the sections in the initial parameters.

S. M. Zavartsev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3409. Rivkin, S. A., An approximate method of calculation for free frames** (in Russian), *New material in building technology* no. 7, Kiev, Gos. Izd-vo Lit. po Str-vu i Arkhitekture, SSSR 1955, 178-190; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12060.

A simplified convergence method is described for the calculation of plane frames under horizontal loading. An example of the calculation is given.

A. I. Vinogradov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3410. Omadze, G. V., An approximate calculation for plane frames subject to horizontal reactions** (in Russian), *Trud Gruz. Politekh. In-ta* no. 6 (47), 24-31, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12061.

An investigation is carried out of the approximate calculations for plane skeletal frames subject to horizontal nodal forces; this was done by the determination of the linear transposition of the joints at the expense of discarding all the side-terms in the system of mutual equations for the transpositions. Examples are cited of the approximate determination of the lowest frequency for the horizontal vibrations of the frames by the energy method (by static nodal transpositions), disregarding the kinetic energy of the bracing mass.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3411. Falk, S., Computation of open frames according to the reduction method**, *Ing.-Arch.* **26**, 1, 61-80, 1958.

Paper is the continuation and generalization of a preceding one [AMR 4 (1958), Rev. 4951] and studies open frames made from straight members. It is shown that the parts of such frames may always be replaced by a definite combination of a compression and a rotational spring called "coupled spring." With the aid of this concept, the frames may be reduced to one or several continuous beams, according to the type of loading. The method uses the matrix formulation and should, therefore, be easily programmed on electronic computing machines.

Three numerical examples are given. A third (and last) paper is announced, which will cover the field of closed frames.

C. Massonnet, Belgium

**3412. Houghton, D. S., and Chan, A. S. L., The design of a multi-cell box in pure bending for minimum weight**, *Coll. Aero. Cranfield Note* no. 74, 23 pp. + 11 figs., Nov. 1957.

**3413. Globonik, St., Analytical and graphical methods for determination of maximum boundary stresses in eccentrically loaded elements of circular hollow cross section without consideration of the tension zone** (in Serbian), *Naše Građevinarstvo* **11**, 7, 189-193, July 1957.

Simplified structural analysis of hollow circular elements built of materials of negligible tensile strength, e.g., chimneys in plain concrete, concrete blocks, also gives tabulated values for variable dimensions and eccentricity. The method is applied to an example and the results are compared with those published in Emperger's "Handbook of reinforced concrete (Handbuch für Eisenbeton)."

J. J. Polivka, USA

## Structures: Composite

(See Revs. 3359, 3638, 3671)

## Machine Elements and Machine Design

(See also Revs. 3305, 3342, 3426)

**3414. Gendzekhadze, T. N., Some problems in the kinetic design of three-dimensional cam mechanisms** (in Russian), *Trudi Mosk. Aviats. In-ta* no. 72, 4-27, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11299.

An examination is made of the building up of the equations of the theoretical and working surfaces of three-dimensional cam mechanisms with a rocking arm. Equations were obtained for the evolutes of the curves, cut out with theoretical surfaces in the body of the cams. These equations open up the possibility of getting the initial data for the preparation of flat patterns on which the task of working surface making is carried out for the cams being examined. An example is given to clarify the exposition.

S. G. Kislitsyn

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3415. Kalinsky, B. V., Calculation of the spoked wheels of railway rolling stock** (in Russian), *Trudi Bezbitsk. In-ta Transp. Mashinostr.* no. 13, 151-194, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9666.

The two-dimensional problem is examined, with reference to A. P. Korobov. Author assumes that the forces arising at the point of junction of the spoke with the felloe are uniformly distributed over a distance corresponding to the pitch of the spokes.

A differential equation of the curved axis of the rim is obtained, and expressions are given for the displacements and internal stresses for different cases of application of the load. An example is discussed of the calculation of a wheel for a C<sup>Y</sup>-series locomotive, with 19 spokes.

Yu. M. Tarnopol'skii

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3416. Thomas, A. K., Design of spiral bevel gears with cycloidal tooth length curves**, *Engineering* 186, 4829, 416-419, Sept. 1958.

Graphical investigation is presented of form of tooth length curve on pitch plane of basic crown gear as applied to less-known cycloidal case, including consideration of localized tooth length bedding. Guidance is stated for standard and exceptional cutting conditions on spiral bevel gear generators employing generating roll motion in connection with single- and multiple-start cutter heads with trapezoidal tools. Mathematical determinations of spiral angle are given for both sets of conditions.

L. R. Koenig, USA

**3417. Zhgolova, T. S., Planetary and differential gear mechanisms** (in Russian), *Trudi Mosk. Aviats. In-ta* no. 72, 28-54, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11306.

The relationship is investigated between the transmission systems and "coefficient of useful action" of planetary mechanisms in closed differentials. For the latter the question is examined of their motion in conditions where the motion moment is independent of the angular velocity.

S. G. Kislitsyn

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3418. Hinkle, R. T., Linkages by graphical synthesis**, *Prod. Engng.* 30, 5, 40-43, Feb. 1959.

Author's methods simplify the development of linkages to generate specific functions. Also supplied are working examples that illustrate the three basic problems and show how to solve them.

From author's summary

**3419. Hirschborn, J., Synthesis of four-bar mechanism**, *J. Appl. Mech.* 25, 3, 349-351, Sept. 1958.

Author in his previous paper [*J. Appl. Mech.* 24, 1, 22-24, Mar. 1957] has indicated a somewhat different approach to the problem of synthesis of four-bar mechanism, other than the usual vectorial method using complex algebra. In this method, which the author has termed as method of components, vectors are resolved into Cartesian coordinates. Three vectorial equations defining the configuration, velocity, and acceleration are replaced by six algebraic equations containing thirteen variables, and problems in which seven of these variables are prescribed may be solved. Author's conclusion on the discussion of the paper [*J. Appl. Mech.* 24, 4, 637-639, Dec. 1957] points out that it is an alternative simpler method and not an attempt to replace the elegant vectorial method.

In the present paper, author has applied his method to design a linkage which would give prescribed maximum and minimum angular velocities of the driven crank with a specified constant angular velocity of driving crank and a given length of fixed link. The analysis leads to a cubic equation in extreme values of angular velocity of connecting rod and which contains two unknown quantities, thus indicating that the problem has infinite number of solutions. Definite result is obtained by assuming a value for either of the extreme values of angular velocity of connecting rod, within the limits set by two criteria equations. The results are applied to two cases, one of oscillating-lever mechanism and the other of double-crank mechanism. The paper of Meyer Zur Capellen [AMR 10, (1957), Rev. 3538] develops methods of determining the position at which the velocity of the driven crank will have maximum and minimum values.

B. M. Belgaumkar, India

**3420. Sherwood, A. A., The mechanical generation of simple harmonic motion by three-dimensional linkages**, *Austral. J. Appl. Sci.* 9, 2, 96-104, June 1958.

Paper presents and analyzes three-dimensional mechanisms developed from plane linkages for mechanical generation of exact linear and approximate angular simple harmonic motion (s.h.m.). The advantage claimed for the mechanism, giving exact linear s.h.m. making use of the third-dimension for correction of the obliquity effect, against the double-slider crank chain, usually known as Scotch-yoke, is the replacement of one sliding pair by a turning pair. However, the mechanism brings in two additional disadvantages, one of replacing the simple turning pair between the driving crank and the connecting rod by ball joints or their kinematic equivalents, the other of considerable side thrust on the remaining sliding pair. The plane and space mechanism for approximate angular s.h.m. is only an extension of Freudenstein's method [AMR 8, (1955), Rev. 1554] by which a four-bar linkage can be designed to generate a function which is accurate at precision points but which is approximate between these points.

Though from the practical point of view the Scotch-yoke or the eccentric cam with flat follower for linear s.h.m., and the eccentric cam with oscillating follower or the Scotch-yoke with rack and pinion, have definite advantage over the mechanisms developed in the paper, it is important to note that, theoretically at least, other mechanisms are possible.

B. M. Belgaumkar, India

**3421. Nikitina, I. P., Selection of some parameters for complex gear lever mechanisms fitted with a checking device** (in Russian), *Trudi Mosk. Aviats. In-ta* no. 72, 55-72, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11305.

A mechanism is examined consisting of a planetary transmission with, joined to it, a two-way carrier group. Different arrangements of such a mechanism might serve for obtaining loss of strength of the driven link for some length of time (together with the customary cam and lever mechanisms used for this purpose). The tracks followed by one of the points of the driven link are determined, for the different schemes applicable for such a mechanism, and some brief suggestions are made for the selection of some of its parameters.

M. Ya. Kushul'

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3422. Artobolevskii, I. I., Mechanism describing conical-section pedal curves** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **105**, 1, 38-41, Nov. 1955.

**3423. Frenzel, W., and Muller, P. G., Examination of a pneumatic spinning bobbin drive** (in German), *Faserforsch. u. Textiltech.* **9**, 7, 273-285, July 1958.

With a model of a cotton ring spindle, driven by air as current medium after the principle of the free jet turbine (Pelton wheel), theoretical and practical examinations were made. The theoretical examinations showed that with such a drive revolutions of the spindle may be obtained which surpass by far those of the usual bobbin drives. Test stand and spinning experiments, however, demonstrated a strong load dependence of the spindle drive during the spinning process. In consequence of the strong dropping of the rotation-speed and of the low efficiency of the installation, the pneumatic spinning bobbin drive is not useful for normal ring spindles. For simple winding processes or perhaps for larger can spindles this kind of drive may be more suitable and show more favorable working properties.

From authors' summary

## Fastening and Joining Methods

(See also Revs. 3385, 3386, 3387)

**3424. Schijve, J., Ultrasonic resonance testing of glued metal joints**, *Aircr. Engng.* **30**, 355, 269-271, Sept. 1958.

The excitation response of a glued metal joint depends upon the extent of the actual glued area. It thus becomes possible to detect voids in the glue by means of ultrasonic frequency excitation. In a perfectly glued joint the first natural frequency is the mode corresponding to the glue acting as a massless spring and the sheets as rigid bodies. The absence of this low frequency is taken as the indication of an incompletely glued joint. Test data taken to confirm the analytical analysis presented seem to substantiate the conclusions reached.

J. P. Vidosic, USA

**3425. Bakshi, O. A., and Kulikov, G. D., Investigation of deformation in automatic vibro-arc welding** (in Russian), The renewing of worn-out components by means of automatic vibro-arc welding, Chelyabinsk, 1956, 99-125; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12200.

It is shown that the deformation when using the automatic vibro-arc welding system for components of cylindrical shape is several times smaller by comparison with other methods of welding. But they still occur at the expense of local plastic deformation. Here not only longitudinal deformations are formed but distortion of the samples. Theoretically, arising from the presentation of "shrinkage forces", the authors give an explanation for the process of component distortion as due to welding along the screw line. Experiments carried out on welding of rollers with a diameter of 20-50 mm and made of steel 20, wire of steel 60, at a vibrations frequency of 100 Hertz and their amplitude 1.5-2.0 mm, made it possible to establish that the deformations increase with the extension

of the welding zone and increase of the initial eccentricity, and also in the result of the preliminary cold setting, but decrease with increase of diameter of the samples and increase of the amount of cooling liquid.

G. A. Nikolaev

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3426. Blodgett, O., The efficient use of welded steel in machine design**, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-223, 12 pp.

**3427. Singleton, O. R., Jr., Abrasion soldering**, *Welding J.* **38**, 1, 34-36, Jan. 1959.

At temperatures above 700 F, high-zinc solders become molten and alloy readily with aluminum when the aluminum surface is subjected to a slight abrading action under the molten solder.

From author's summary

## Rheology

(See also Revs. 3543, 3546, 3579)

**3428. Ivanova-Chumakova, L. V., and Rehbinder, P. A., The laws of development of shearing strain and stress relaxation in elastomers and their solutions** (in Russian), *Kolloid Zh.* **18**, 5, 540-546, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9791.

An instrument is described (similar to that of D. M. Tolstoi) for studying the process of stress relaxation in disperse and high-molecular systems, founded on the principle of simple shear of the test material between two parallel plates.

It is found that the deformation properties of polyisobutylene can be approximately described by means of a four-element, mechanical model, the retarding element of which possesses nonlinear viscosity and follows, in shear, the expression

$$\frac{d\epsilon}{dt} = aP \frac{\epsilon_m - \epsilon}{\epsilon_e} \quad [1]$$

where  $P$  = shear stress,  $\epsilon_e$  elastic deformation at a particular time instant,  $\epsilon_m$  equilibrium plastic deformation,  $\tau$  time,  $a$  a constant.

Examination of the process of stress relaxation shows two possible forms thereof: true relaxation by transition from a state of elastic to residual deformation; and elastic relaxation, due to the elastic hysteresis of the material.

An equation is derived for the elastic relaxation of a medium possessing linear elasticity and viscosity, the retardation of which proceeds according to Eq. [1].

Authors point out that the theoretical constructions agree satisfactorily with the experimental results for tests of relatively short duration, in which the value of the true relaxation is small.

N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3429. Nikolaev, B. A., and Beganskaya, L. S., Measurement and control of the flexible-elastic and plastic-viscous properties of dough** (in Russian), Trans. of the 3rd All Soviet Conf. on Colloid Chem. 1953, Moscow, Akad. Nauk SSSR, 1956, 209-222; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12299.

The apparatus is described (of the D. M. Tolstoi type) for use in the investigation of the rheological characteristics of dough, based on the principle of longitudinal shear of the system being examined, between two parallel plates, which during the carrying out of the experiment were disposed inclined to the horizon. The shearing action of the upperplate occurs under the action of the tangential component of the force of gravity. Following the curves of the kinetics of the development and fall of the deformation, calcula-

tions were made for the rheological characteristics of the dough. Together with the determinations of the already known deformation characteristics, measurements were made of three proposed characteristics, the so-called conditional plasticity, dilution intermittently and consolidation during deformation. The influence was examined of the speed of the deformation of shear on the character of the development and drop of deformation in relation to time, the effect of humidity and temperature of the dough, the contents of its basic fractions, the sustaining power of the dough after mixing and preliminary thermal treatment of the flour. The attempt is recorded of trying to establish the relation between the elastic-viscous characteristics of the dough and the physical properties of the baked bread.

N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3430. Rusanov, B. V., Equations of the theory of dissipating viscosity (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* 104, 3, 368-371, Sept. 1955.

## Hydraulics

(See also Revs. 3234, 3355, 3438, 3449, 3539)

Book—3431. Bano, I., Problems in hydraulics [Hydraulika v Prikladoch], Bratislava, Slovenske Vydavatel'stvo Technikej Literatry, 1956, 681 pp.

This large volume contains 167 completely elaborated problems covering hydrostatics; flow in open channels, artificial and natural, uniform and nonuniform; flow in pipes, through outlets, valves, under gates, over weirs, through constrictions, in ship locks; movement of ground water; seepage; wells, level control. All problems are of practical importance, therefore this manual is very useful for hydraulic engineers. Author followed idea of a German book "Grund- und Wasserbau in praktischen Beispielen" by O. Streck, 1950, and a Russian book "Gidravlika v zadachakh" by A. Gorchin and M. Chertousov, 1932. Information is based mostly on the Russian literature. Many methods applied in the book are little-known here and could be of interest for our readers. Some American names, like R. E. Horton, are transformed in Russian transliteration to Charton (read Kharton instead of Khorton). 445 figures and 212 numerical tables illustrate the valuable book. Print is of high standard.

S. Kolupaila, USA

3432. Pishchenko, I. A., Movement of water through a submerged spillway with an apron (threshold) (in Russian), *Trudy Kievsk. Gidromelior. In-ta* 1954, 43-49; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11589.

A theoretical investigation is undertaken of the criteria governing the submerging of the spillway on the assumption that the depth of the apron does not differ much from the critical and that "the losses of energy in the installation are approximately the same as they would be if the installation had not been there." No reference is cited publishing the solution to this problem. The type of flow regime beyond the apron is investigated. Substitution of the bottom regime by the surface one is determined by the equality of specific energies; this question too is solved on the basis of the principle of the quantity of movements; no comparison of the solutions is given.

D. I. Kumin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3433. Mashkileison, A. A., and Spivak, E. B., Investigation of the flow from under a board on the summit of a spillway of practical profile (in Russian), *Sb. Nauch. Stud. Rabot. Mosk. In-ta Inzh. Vod. Kh-va* no. 3, 22-27, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4272.

Authors describe the results of several tests made on a model of a curvilinear spillway 24 cm high in a trough 25.8 cm wide. The tests were undertaken to verify the discharge formula in the case of flow from under the floodgate

$$Q = \varphi \epsilon ab \sqrt{2gH_0}.$$

The authors note the obvious circumstance that the pressure on the overflow part of the spillway during flow from under the floodgate decreases as compared with the free overflow, and they confirm the low values recommended by F. I. Pikalov [I. I. Agroskin, G. T. Dmitriev, F. I. Pikalov, *Gidravlika* 1954] of the values  $\mu = \varphi \epsilon$  which turned out to be 8 to 33% lower than the test values. In this connection a graph shows the relationship of the deviations from the value of the relative rise of the floodgate ( $a/H$ ). The test relationship  $\varphi$  to the pressure on the summit  $p/\gamma$  and to the value  $a$  of the rise of the floodgate is also given.

A. R. Berezinskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3434. Rurua, G. B., A water distributor with inclined diaphragm (in Russian), *Trudy Gruz. N.-i. In-ta Gidrotekhn. i Melior.* 4, 17, 180-183, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6700.

It is suggested that on canals with heavy gradients use be made of distributors in the form of pits ending in a sluice valve. The longitudinal wall of the distributor is provided with an opening for feeding water to the irrigation ditch. To extinguish the energy of the flow at the beginning of the pit, an inclined concrete or ferro-concrete diaphragm is installed between the longitudinal walls.

It may be mentioned that the use of an inclined diaphragm (a "damping shield") for extinguishing the flow energy has already been suggested by F. I. Pikalov [*Vestn. s.-Kh. Nauki, Melior. i Gidrotekhn.* no. 1, 71-79, 1941].

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3435. Yuldashev, B., Generalized expressions for the critical and conjugate depths in parabolic cross sections (in Russian), *Trudy Rashkentsk. In-ta Inzh. Irrigatsii i Mekhaniz. S. Kh.* no. 2, 171-180, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8943.

A derivation is given for the equation of the critical and conjugate depths for cross sections of channels described by parabolas of the form

$$x^{2n} = 2py.$$

For  $n = 0.5$ , and  $n = \infty$  the known expressions for the rectangular and triangular cross sections are obtained, while for  $n = 1$ , the equivalent equation is that of a quadratic parabola, obtained by L. S. Bashkirova and by I. I. Agroskin.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3436. Semenida, V. I., Verification of the calculation of unsteady motion in an open channel (in Russian), *Gidrotekh. i Melioratsiya* no. 7, 51-52, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4265.

Paper reports on tests made in a large canal (7000 m in length, 12.5 m width at the bottom) to verify the results of the calculation of unsteady motion caused by variations of the flow at entry to the canal.

The test data confirm the accuracy of the calculation (which is sufficient from a practical point of view) which was made by the method of instantaneous conditions.

V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3437. Ishii, Y.,** On experimental considerations of the relation between runaway speeds and cavitation phenomena of Kaplan turbine, *Bull. JSME* 1, 2, 178-184, June 1958.

Tests with 200-mm diam 5-, 6-, 7- and 8-vane runners with photographs and sketches of cavitation show two types of cavitation at runaway conditions, one with similar bubble formation and areas on every blade; the other similar on every other blade, adjacent blade cavitation being different. Diagrams with unit rpm [ $n_R = n(H)^{1/2}$ ] ordinates as function of cavitation coefficient ( $\sigma$ ) under varying gate openings and runner-vane angle settings show test points and results. Reviewer believes that similar data at best efficiency and incipient cavitation conditions would greatly enhance the value of these interesting experiments. A. Hollander, USA

## Incompressible Flow

(See also Revs. 3198, 3436, 3493, 3505, 3528, 3540, 3670)

**Book—3438. Jaeger, C.,** Engineering in fluid mechanics (translated from German by P. O. Wolf), 2nd. ed., New York, St. Martin's Press, Inc., 1957, xviii + 529 pp. \$11.50.

See AMR 10 (1957), Rev. 2945.

**3439. Kline, S. J., and Dean, R. C., Jr.,** On the central unresolved fluid-mechanics problems of the mechanical engineer, ASME Ann. Meet., New York, N.Y., Nov./Dec. 1958. Pap. 58-A-211, 8 pp.

**3440. Donnelly, R. J.,** Experiments on the stability of viscous flow between rotating cylinders. I. Torque measurements, *Proc. Roy. Soc. Lond. (A)* 246, 1246, 312-325, Aug. 1958.

The onset of instability in the viscous flow between rotating cylinders was measured in a rotating cylinder viscometer in which the torque transmitted to a freely suspended outer cylinder was measured as a function of the rate of rotation of the inner cylinder for a series of standard viscosity oils. The onset of instability was characterized by a discontinuity in slope and magnitude of the effective viscosity as a function of rotational period. Measurements are in good agreement with Chandrasekhar's theoretical predictions for narrow gap geometries (Taylor problem) as well as those for the general case where the gap width is not small compared to the mean radius. L. M. Grossman, USA

**3441. Chandrasekhar, S.,** The stability of viscous flow between rotating cylinders, *Proc. Roy. Soc. Lond. (A)* 246, 1246, 301-311, Aug. 1958.

The classical work of Taylor on this problem was restricted to the case where the difference in the radii of the two cylinders was small compared to the mean radius [ $R_2 - R_1 \ll 1/2 (R_1 + R_2)$ ].

Author treats the appropriate eigenvalue problem without this restriction in which the eigenfunctions are expressible as certain linear combinations of Bessel functions. Detailed numerical results are obtained for the case when the ratio of the radii of the two cylinders is one-half. L. M. Grossman, USA

**3442. Kito, F.,** On vibration of an ideal fluid contained in an annular region bounded by two eccentric circular cylinders (case of finite amplitude), *Bull. JSME* 1, 3, 293-297, Aug. 1958.

Ideal liquid is assumed to fill the annular space between two infinite eccentric circular cylinders, whose axes are parallel. Author considers pressure distribution when the inner boundary vibrates transversely while the outer boundary remains fixed. G. Power, England

**3443. Altenhoff, J.,** A test of the uniqueness of solutions for problems of nonsteady flow under given boundary conditions, *J. Aero. Sci.* 25, 3, 210-212 (Readers' Forum), Mar. 1958.

**3444. Mabey, D. G.,** A special case of swirling viscous flow, *J. Aero. Sci.* 25, 3, 212-214 (Readers' Forum), Mar. 1958.

**3445. Mallick, D. D.,** Nonuniform rotation of an infinite circular cylinder in an infinite viscous liquid (in English), *ZAMM* 37, 9/10, 385-392, Sept./Oct. 1957.

Two problems concerned with unsteady flow of viscous fluid in cylindrical coordinates are solved by author. The first is that of an infinite viscous fluid initially rotating as a solid body. About the same axis a cylinder of finite radius, initially at rest, suddenly begins to rotate at an arbitrary angular velocity. The Navier-Stokes equations are solved to obtain  $v = v(r, t)$  for the given boundary conditions. The second problem is that of a viscous fluid inside a circular cylinder in which both the fluid and cylinder are initially at rest. The cylinder suddenly starts to rotate at a given angular velocity. Again the solution  $v = v(r, t)$  is obtained. The Laplace transformation is employed to solve these problems with contour integration, and residue computation being employed to obtain the inverse transformations. Two interesting definite integrals involving Bessel functions are evaluated from the resulting solutions, utilizing the initial conditions; expressions for torque coefficients are also determined. Author's presentation is precise and thorough and his efforts have resulted in obtaining additional solutions to cylindrical viscous flow problems. R. B. Banks, USA

**3446. Dolmatov, K. I.,** Irregular flow about a sphere by a stream of viscous incompressible liquid in terms of Oseen's approximation (in Russian), *Trudi In-ta Matem. i Mekhan. Akad. Nauk USSR* no. 16, 79-86, 1955; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11643.

The problem is examined of the irregular flow about a sphere by an unbounded stream of a strongly viscous incompressible liquid over a sufficiently large interval of time after the commencement of the motion. As the initial equations Oseen's equation and the equation of continuity are adopted. The field of velocities of the liquid are determined with the aid of the operational method. The formulae obtained are somewhat unwieldy. It is shown that in the zero approximation Stokes's formulae are obtained for the slowly steadying flow about a sphere by a stream of viscous incompressible liquid. The reaction forces of the stream on the sphere are not determined in the paper. V. N. Arkhipov

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3447. Golubeva, O. V.,** Basic trends in the study of two-dimensional motion of an ideal liquid (in Russian), *Uch. Zap. Mosk. Obl. Ped. In-ta* 43, 27-34, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11537.

A short review is given of the results of a series of works carried out by the author and his pupils and devoted to the investigation of the motion of an incompressible liquid in thin films on curved surfaces. The basic equations relating to this motion are put forward. Present and possible future applications of the theory are indicated (questions relating to filtration, to dynamic meteorology, to turbine computations) and the trend to further development is suggested. A. A. Il'ina

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3448. Pavlin, O. K.,** Nonstationary circular motion of viscous liquid with a variable coefficient of viscosity (in Russian), *Nauch. Zap. Chernivetsk. In-ta* 19, 64-69, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11640.

An investigation is made of the irregular motion of a viscous, incompressible liquid between two co-axial cylinders with a viscosity coefficient dependent on temperature. In the initial moment of time one of the cylinders has an angular velocity differing from

zero; the temperature of all the particles of the liquid is the same and equal to the temperature of the walls. After this picture of the cylinder, the principle has to be sought for the decrease of its angular velocity with time in the absence of heat exchange between the liquid and the walls. The problem is solved, making use of the following very rough and ready assumptions: the distribution of velocity in the layer of liquid between the cylinders is the same as in the solution of the corresponding problem of stationary flow; the temperature at all points in the liquid is equal and its change is determined by the dissipation of energy in consequence of the action of viscosity. It is accepted that the magnitude, inversely to the coefficient of viscosity, depends linearly on the temperature. The relations were found between the angular speed of rotation of the cylinder and temperature of the liquid, and the time.

G. G. Chernyi

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3449. Semenov, N. I., Hydraulic resistance of mixed gas-liquid flow in horizontal pipes** (in Russian), *Doklady Akad. Nauk SSSR* (N.S.) 104, 4, 513-516, Oct. 1955.

**3450. Belotserkovskii, S. M., Spatial unsteady motion of a lifting plane** (in Russian), *Prikl. Mat. Mekh.* 19, 4, 410-420, July/Aug. 1955.

**3451. Idel'chik, I. E., Means employed for the even distribution of gaseous flow in industrial installations** (in Russian), *Khim. Prom-st'* no. 6, 351-357, 1955; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11442.

Recommendations are advanced for calculations for devices to ensure an even distribution of gaseous flow over the working section of various apparatus such as scrubbers, absorbers, heat-exchangers, filters, etc., in cases where the section of the feed pipe is less than the working section of the apparatus. Methods are examined to even out the flow by means of resistances, concentrated here and there along the section of the pipe, and with the help of guider vanes. On the basis of work done previously by the author calculation formulae are given and suggestions made for the selection and use of single (self-contained) level-adjusting grids, of assemblies of grids, guiding vanes and combination devices of vanes and grids. Some suggestions are also put forward regarding the use of short diffusers with dividing walls.

V. G. Gal'perin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3452. Mimura, Y., The flow with wake past an oblique plate** (in English), *J. Phys. Soc. Japan* 13, 9, 1048-1055, Sept. 1958.

Pressure distributions and free streamlines are calculated for inclined two-dimensional flat plates by notched hodograph method of Roshko. Calculated values are compared with experiments of Fage and Johansen, with fair agreement. Discrepancies are greatest for small angles of attack.

From author's summary by D. W. Appel, USA

## Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 3438, 3492, 3495, 3498, 3510, 3511, 3512, 3529, 3534, 3548, 3555, 3569, 3623, 3630, 3631, 3636, 3667, 3679)

**3453. Miles, J. W., On the disturbed motion of a plane vortex sheet**, *J. Fluid Mech.* 4, 5, 538-552, Sept. 1958.

A formal solution to the initial-value problems for a plane vortex sheet in an inviscid fluid is obtained by transform methods. The

eigenvalue problem is investigated and the stability criterion determined. This criterion is found to be in agreement with that obtained previously by Landau (1944), Hatanaka (1949), and Pai (1954). It is also established that supersonic disturbances may be unstable. Finally, an asymptotic approximation is developed for the displacement of a vortex sheet following a suddenly imposed, spatially periodic velocity.

From author's summary by S. I. Pai, USA

**3454. Reyn, J. W., Compressible inviscid flow near the end of pointed afterbodies**, *J. Aero/Space Sci.* 25, 12, 787-788 (Readers' Forum), Dec. 1958.

**3455. Pitts, W. C., and Nielsen, J. N., A body modification to reduce drag due to wedge angle of wing with unswept trailing edge**, *NACA TN* 4277, 13 pp., July 1958.

Ward's slender-body-theory formula for zero lift drag includes a term which depends only on the body shape and axial slopes at the base. Report investigates possibility of reducing drag below that obtainable by the area rule modification where this term is not considered. By varying the body base slopes of a delta-wing cylindrical-body combination with unswept trailing edge, constant trailing edge angle and span-to-diameter ratio of 3, a reduction of 12% was found. Changes in base drag were neglected. Significance of viscous interaction phenomena at the trailing edge is qualitatively discussed.

R. J. Hakkinen, USA

**3456. Predvoditelev, A. S., The coefficients of heat conductivity and viscosity of liquids and compressed gases** (in Russian), *Sb. Posvyashch. Pamyati Akad. P. P. Lazareva*, Moscow, Akad. Nauk SSSR, 1956, 84-112; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9124.

**3457. Van Dyke, M. D., Second-order slender-body theory—axisymmetric flow**, *NACA TN* 4281, 46 pp., Sept. 1958.

Axisymmetric flow at both subsonic and supersonic speeds is considered, the result being applied to bodies of revolution at zero incidence. The theory is set out with great clarity, the solution being obtained by an iterative procedure, using the first-order solution. The analytic form of the solution simplifies considerably in transonic flow.

Comparison with exact theoretical pressure distribution on cones in supersonic flow shows that the present approximation gives a considerable improvement over first-order slender body theory. Results also give good agreement with measured pressures on a parabolic-arc spindle at transonic speeds.

The theory fails, at least locally, near stagnation points. It is shown how the method can be corrected for subsonic flow past a body that has sharp or round ends (the correction in the latter case being based on flow past a paraboloid of revolution). The theory is compared with experimental results for subsonic flow past an ellipsoid of revolution.

A. W. Babister, Scotland

**3458. van de Vooren, A. I., and DeJager, E. M., Calculation of aerodynamic forces on slowly oscillating rectangular wings in subsonic flow**, *Nat. LuchtLab. Amsterdam NLL-TN F. 192*, 16 pp. + 28 append. + 11 tables + 19 figs., 1956.

**3459. Dombrovskii, G. A., Approximate solution of a problem on subsonic flow past a shaped body, taking circulation into account** (in Russian), *Doklady Akad. Nauk SSSR* (N. S.) 103, 6, 985-987, Aug. 1955.

**3460. Taylor, R. A., Pressure distributions at transonic speeds for bumpy and indented mid-sections of a basic parabolic-arc body**, *NASA Memo.* 1-22-59A, 8 pp., + 12 figs., Feb. 1959.

The measured static-pressure distributions at the model surface and in the surrounding flow field are presented for a basic parabolic-arc body having a fineness ratio of 14 and for three additional

bodies obtained by modifying the basic parabolic-arc body along the middle portion of the body length by adding a bump, by indenting, or by quadrupole shaping. The data were obtained with the various bodies at zero angle of attack. The Mach number varied from 0.80 to 1.20 with a corresponding Reynolds number (based on body length) variation of  $27 \times 10^6$  to  $38 \times 10^6$ .

From author's summary

**Book—3461. Miles, J. W., The potential theory of unsteady supersonic flow**, Cambridge University Press, New York, 1959, xii + 220 pp. \$8.50.

Book contains twelve chapters on linearized unsteady flow problems and one chapter on nonlinear problems, as follows: (1) The linearized equations, pp. 1-17; (2) The transformation of the subsonic wing equations, pp. 18-25; (3) The transformation of the supersonic wing equations, pp. 26-38; (4) Reduction to steady flow, pp. 39-48; (5) Two-dimensional problems, pp. 49-60; (6) Simple planforms, pp. 61-68; (7) The rectangular wing, pp. 69-87; (8) The quadrilateral wing, pp. 88-94; (9) Slender wing problem, pp. 95-127; (10) The delta wing, pp. 128-146; (11) The low-aspect-ratio rectangular wing, pp. 150-157; (12) Slender non planar bodies, pp. 158-177; and (13) Nonlinear problems, pp. 178-186. In addition there is an Appendix on reverse flow theorems and a list of more than three hundred references, of which fifty nine were written by the author.

The readers are assumed to have some fundamental knowledge of steady linearized supersonic flow. The monograph stresses formulation of the problems, reduction of linearized equations to normal forms, and the application of integral transforms. References to other approaches are given in author's preface. This is a revised version of the author's original monograph "Unsteady supersonic flow" [USAF, ARDC, 1955]. The presentations are clear and elegant. The theories are important in prediction of unsteady aerodynamic forces on thin wings and slender bodies in supersonic flight. Graduates and engineers in the related field should find the monograph enjoyable and rewarding.

The printing is comfortable to read. Nevertheless, a few misprints are observed;

1. On page 43, line 8,  $\Phi^{(b)}$  should be  $\Phi^{(a)}$
2. On page 45, line 12 from the bottom,  $M_{2+1}$  is  $M_{2+1}$
3. On page 84, line 7, (7.3.10) should be (7.3.1)
4. On page 94, line 1, it seems that  $\psi^{(2)}$  should be  $\psi$
5. On page 123, in Eq. (9.8.6),  $L\phi^*$  should be  $L\phi (=L^{-1}L\phi^*)$

It is remarked that the linearized unsteady boundary-value problems are generally decomposed into two parts—the symmetrical and the antisymmetrical. The symmetrical unsteady part is of less practical importance and is a simpler mathematical problem since the boundary-value problem is not mixed. For nonlinear problems, the effect of the symmetric part enters. The reviewer believes the (total) velocity potential  $\lim_{z \rightarrow +0} \phi(x, y, z, t)$  in  $R$  (in the plan of

the wing but outside of the planform and the wake) [c.f., p. 181, on  $R$  remains  $\phi = 0$ ] is in general not zero. Since the linearized first-order approximation of the symmetric part can be used to determine the second approximation of the antisymmetric part (page 180), which determines the lift and moment distribution, the condition on  $\psi$  in  $R$  remains  $\psi(x, y, 0, t) = 0$ . This does not effect the example (two-dimensional) in which  $\phi$  is identical zero in  $R$ .

W. H. Chu, USA

**3462. Evans, M. W., and Harlow, F. H., Calculation of unsteady supersonic flow past a circular cylinder**, *ARS J.* **29**, 1, 46-48 (Tech. Notes), Jan. 1959.

A numerical calculation method has been used to determine the two-dimensional, transverse flow pattern of air moving at supersonic speeds past an infinite circular cylinder. Details are presented concerning initial flow stages after the cylinder had been impulsively accelerated to a fixed speed. Information is presented

in particular about the lateral propagation rate of disturbance, the development of detached shock, stream lines and streak lines, and the drag and isopycnics.

From authors' summary

**3463. Samanich, N. E., Pressure drag of axisymmetric cowls having large initial lip angles at Mach numbers from 1.90 to 4.90**, *NASA Memo.* 1-10-59E, 4 pp. + 2 tables + 8 figs., Jan. 1959.

Experimental cowl pressure drag coefficients of nine elliptically contoured cowls with various external lip angles and projected areas at zero angle of attack and at Mach numbers from 1.90 to 4.90 were compared with two-dimensional shock-expansion theory. An empirical chart is presented which enables the estimation of pressure drags of cowls having or approximating an elliptic contour.

From author's summary

**3464. Charwat, A. F., A modified model of the supersonic laminar wake**, *J. Aero/Space Sci.* **25**, 12, 796-797 (Readers' Forum), Dec. 1958.

An hypothesis is offered for the observed base pressure decrease with decreasing Reynolds number. Continual compression, idealized to multiple compression "cells," is shown to conform conceptually with experimental evidence and affords qualitative comparison of two-dimensional and axisymmetric behavior.

J. R. Baron, USA

**3465. Wong, H., and Williams, J. C., III, A study of the feasibility of the direct condensation of a supersonic stream**, *AFOSR TN 58-712* (Univ. So. Calif. Engng. Center Rep. 56-204; ASTIA AD 162 247), 14 pp. + 12 figs., July 1958.

**3466. Linnell, R. D., Calculations by the method of characteristics**, *Aero. Engng. Rev.* **17**, 3, 39-44, Mar. 1958.

A method of programming a high-speed electronic computer for calculation of axially symmetric supersonic flow around bodies of revolution is given. Difference equations are used to replace the characteristic equations of the flow. The computation involves the construction and storage in the computer of a characteristic grid similar to that used in the well-known graphical design of the two-dimensional Laval nozzles. A discussion of computer logic and its relationship to the computer capabilities and capacity is included.

E. K. Parks, USA

**3467. Schlichting, H., and Feindt, E. G., Calculation of frictionless flow for a given two-dimensional cascade at high subsonic speeds** (in German), *Forsch. Geb. Ing.-Wes.* **24**, 1, 19-28, 1958.

A simple approximate method based on the Prandtl-Glauert rule is developed for inviscid subsonic flow through a linear cascade. A compressible flow through a cascade at a given Mach number is related to an incompressible flow through a corresponding cascade with the same blade profile but with a smaller pitch-chord ratio and with a larger stagger. The incompressible flow through the corresponding cascade can be estimated using a conventional method [AMR 8 (1955), Rev. 3482]. Many examples at different stagger and different pitch-chord ratio are shown. The predicted velocity distributions around a blade are compared with experimental values for a cascade with zero stagger at angle of attack  $0^\circ$  and  $10^\circ$ . The agreement is good up to  $M = 0.6$  but the theory underestimates the velocity around the airfoil at a higher Mach number. Although the method is applicable for any cascade, reviewer thinks the prediction is less accurate for a staggered cascade and for large flow turning.

Y. Senoo, USA

**3468. Graham, E. W., Approximation of optimum lift distributions from their spanwise moments**, *Douglas Aircr. Co. Rep.* SM-23021, 11 pp., Dec. 1957.

In some cases the minimum drag value for given total lift in supersonic flow may be determined by solving a two-dimensional

potential flow problem. This report outlines one method of approximating the optimum distribution of lift for a planar wing from information contained in the solution of the potential flow problem.

From author's summary by G. E. Nitzberg, USA

**3469. Oswatitsch, K., Pressure recovery in ram-jets at high supersonic speeds** (in German), *Dtsch. Versuchsanstalt Luftfahrt* no. 49, 50 pp., Dec. 1957.

This is a reprint of one of the earliest papers ever written on the design of diffusers in ramjets and originally appeared in 1944. In the design contemplated, the air entering the ramjet first passes through a conical shock and then enters an annular region where it passes through further shocks until it becomes subsonic. It then enters the combustion chamber after passing through a subsonic diffuser. The paper is mainly of historical interest now.

K. Stewartson, England

**3470. Portnov, I. G., On stationary regimes of a supersonic gas ejector** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 106-109, Apr. 1957.

Portnov considers a supersonic ejector discharging into a container filled out by a gas. For the proper understanding of the action of such an ejector, the important factor is the correct evaluation of the phenomena on the surface of the body of the ejecting gas. On it there takes place some kind of mixing with the surrounding gas. Portnov distinguishes two parts of the body of the moving gas: active, which gives away a part of its energy, and passive which takes the energy from the active part. Using the equation derived by B. M. Kiselev ["Calculation of one-dimensional gaseous flows," *Prikl. Mat. Mekh.* 11, 1, 177-192, 1947], Portnov calculates the ejector coefficient (i.e., ratio of the passive mass to the active mass) as a function of the pressure ratio. The agreement with the experiments is fairly good.

M. Z. v. Krzywoblocki, USA

**3471. Pitkin, E. T., and Glassman, I., Experimental mixing profiles of a Mach 2.6 free jet**, *J. Aero/Space Sci.* 25, 12, 791-793 (Readers' Forum), Dec. 1958.

**3472. Vinson, P. W., Amick, J. L., and Liepman, H. P., Interaction effects produced by jet exhausting laterally near base of ogive-cylinder model in supersonic main stream**, *NASA Memo.* 12-5-58W, 13 pp. + 22 figs., Feb. 1959.

The experimentally determined interaction effects of a side jet exhausting near the base of an ogive-cylinder model are presented and discussed. The interaction force appears to be independent of main-stream Mach number, boundary-layer condition (laminar or turbulent), angle of attack, and forebody length. The ratio of interaction force to jet force is found to be inversely proportional to the square root of the product of jet stagnation-to-free-stream pressure ratio and jet-to-body diameter ratio.

From authors' summary

**3473. Johnson, R. H., The cone-sphere in hypersonic helium above Mach 20**, *Aero/Space Engng.* 18, 2, 30-35, Feb. 1959.

The cone-sphere body has been studied in hypersonic helium flows at Mach numbers of 22 and 25. The relations between the shock wave and the body were obtained for a series of cone-sphere models with bluntness varying from that of a flat-ended circular cylinder to a hemisphere-cylinder. The experiments have shown that the flow field may be approximated by either the simple sphere flow or the flat circular disk flow within determined ranges of cone-sphere bluntness.

From author's summary

**3474. Oguchi, H., Hypersonic flow near the forward stagnation point of a blunt body of revolution**, *J. Aero/Space Sci.* 25, 12, 789-790 (Readers' Forum), Dec. 1958.

In a theoretical paper on solution of Navier-Stokes equations when flow behind bow wave is considered incompressible, graphical results are given for potential function and local skin coefficient. No attempt is made to identify relevant physical situation for relation of this solution to several others in the literature.

W. C. Griffith, USA

**3475. Goldman, K. L., Hypersonic flow characteristics including real gas effects**, *J. Aero/Space Sci.* 25, 11, p. 728 (Readers' Forum), Nov. 1958.

**3476. Probstein, R. F., Continuum theory and rarefied hypersonic aerodynamics**, Brown Univ., Div. Engng. (WADC TN 58-145; ASTIA AD 155 587), 23 pp. + 4 figs., July 1958.

The problem is considered of predicting mean viscous aerodynamic characteristics, such as surface heat-transfer rate and skin friction, of blunt bodies flying at very high speeds under rarefied gas conditions. At sufficiently high altitudes the appropriate mean free path of the flow becomes too large for the use of boundary-layer theory but not large enough that free molecule concepts apply. It is this "intermediate" regime which is studied.

Based on works of Adams, Hayes, and the author the regimes of rarefied gas flow and the limits of continuum theory are defined and it is proposed that, except "very close" to the free molecule condition (first-order collision regime), the Navier-Stokes equation may be used as a model. This model may not necessarily give the shock-wave structure in detail but it will satisfy overall conservation laws and give a reasonably accurate picture of all mean aerodynamic quantities.

Excluding the first-order collision regime it is shown that in the intermediate regime there are two fundamental classes of problems: a "viscous layer" class and a "merged layer" class, the latter corresponding to a larger degree of rarefaction. For the viscous-layer class there is a thin discontinuous shock wave, but the region between the shock and the body (shock layer) is fully viscous, although the viscous stresses and conductive heat transfer are small at the shock-wave boundary. In this case the use of the Navier-Stokes equations with outer boundary conditions given by the Hugoniot (shock) relations is justified. For the merged-layer class the shock wave is no longer thin and the Navier-Stokes equations are used to give a solution which includes the shock structure and has free-stream conditions as outer boundary conditions.

For a sphere and cylinder it is shown that new exact solutions of the Navier-Stokes equations can be obtained for both the viscous and merged-layer class of problems. To illustrate these solutions some numerical results for stagnation point heat transfer and shock-layer thickness are presented for the viscous layer on a sphere with the assumption of constant density in the shock layer (which is a good approximation at hypersonic speeds). The preliminary calculations when applied to the evaluation of the stagnation point heat transfer on a highly cooled sphere in atmospheric hypersonic flight, corresponding roughly to satellite velocity under rarefied gas conditions, show a behavior with increasing rarefaction somewhat different from that anticipated by many authors.

From author's summary

**3477. Probstein, R. F., Aerodynamics of rarefied gases**, Brown Univ., Div. Engng. (WADC TN 58-228; ASTIA AD 155 819), 26 pp. + 5 figs., July 1958.

Paper attempts to present a simple outline of some general results relating to the aerodynamics of rarefied gases. What is meant by a rarefied gas flow is discussed and the parameters of such a flow are introduced. Paradoxes for both continuum and free molecule flow are noted in connection with the absolute body temperature becoming zero, and it is shown that the paradox may be of practical importance for highly cooled bodies in the free molecule case, although it is not generally important for continuum flow.

Slip and temperature jump are discussed and it is shown that these effects are generally not important when continuum concepts are applicable. A new broad classification of the regimes of rarefied gas flow is then given. It is pointed out that the practically important "intermediate" regime between where boundary-layer theory and free molecule theory is valid may, except "very close" to the free molecule condition, be treated by continuum theory at least for determining mean aerodynamic coefficients.

Free molecule flows are briefly developed and the concept of a first-order collision regime where the local Knudsen number is large but not large enough to ensure the full validity of the free molecule concept is examined. Finally it is shown that there exists a similitude for the pressure forces on bodies, for shear, and for heat transfer for a hypersonic free molecule flow.

From author's summary

**3478. Deriagin, B. V., and Bakanov, S. P., Theory of the flow of a gas in a porous material in the near-Knudsen region, *Soviet Phys.-Tech. Phys.* 2, 9, 1904-1918, May 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* 27, 9, 2056-2070, Sept. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)**

Authors have applied the Chapman-Enskog method of solving the transport equations to calculate the flow of a rarefied gas through porous media by assuming boundaries in the form of randomly distributed spheres. The calculated filtration coefficient shows, as a function of the pressure, a minimum similar to that observed by Knudsen, Gaede and others in their study of gas flow through straight capillaries.

Although authors state "that theoretical attempts to account for this minimum have been unsuccessful," they overlook the fact that this has been done in similar work by Pollard and Present [*Phys. Rev.* 7, p. 762, 1948], who also claimed that there was no theoretical or experimental evidence for the existence of such minima in the case of irregular capillaries and porous media because these minima were actually due to the long free path of the molecules in a straight capillary. However, the Deriagin-Bakanov model applies only to highly porous media, for which the assumption of a long free path is justified.

In applying an exact mathematical method, authors have made an important contribution to the theory of rarefied gas flow through highly porous media.

L. C. Woods, Australia

**3479. Oguchi, H., First-order approach to a strong interaction problem in hypersonic flow over an insulated flat plate, *Aero. Res. Inst., Univ. Tokyo* 24, 1, 30 pp., June 1958.**

Analysis joins a boundary-layer solution with the external inviscid solution by requiring continuity of normal velocity, and all thermodynamic variables at the matching condition. Calculations are made for both air and helium. Numerical results indicate considerably smaller induced pressures than an earlier approximate theory of Lees. Calculations for helium are in good agreement with NACA experiments at  $M = 16$  to 17 by Erickson. These experiments, however, yield values of induced pressure ranging from about 30 per cent to 50 per cent smaller than earlier Princeton experiments in helium at  $M = 11$  to 14 by Hammitt and Bogdanoff.

D. R. Chapman, USA

**3480. Bogdanoff, S. M., and Vas, I. E., Exploratory studies of a spiked body for hypersonic flight, *Heat Transf. and Fluid Mech. Inst., Univ. of Calif.*, June 1958, 187-203.**

Authors have investigated the flow over flat or spherical-nosed axially symmetric blunt bodies with or without a projecting spike. The tests were done at zero angle of attack in a helium hypersonic wind tunnel at a Mach number  $M \approx 14$ , and a Reynolds number  $Re \approx 0.73 \times 10^6$  per inch. The effects of varying the spike length on pressure distribution and heat-transfer rate were studied. The results indicate that this technique can reduce the pressure level by an order of magnitude and the heat-transfer rate to a fraction of

that without the spike. Consequently, it appears to have promising applications in the reduction of drag and heat-transfer rates at hypersonic speeds, where the spike reduces the pressure level to that of slender body and the separated flow remains laminar. For the optimum spike length  $L$  to model diam ( $d = 1/2$  in.),  $L/d = 4$ , the form drag was  $1/10$  and the heat transfer  $1/3$  that of the hemispherical cylinder alone. (For the flat-nosed cylinder the corresponding figures for  $L/d = 4$  were  $1/40$  and  $1/2$ .)

Reviewer would like to note that the data for the flat-nosed cylinder and a discussion of the results can be found in the more recent paper "Preliminary investigations of spiked bodies at hypersonic speeds," *J. Aero/Space Sci.* 26, 2, 65-74, Feb. 1959, by the same authors. The effects of angle of attack on such a configuration is reported in "Supersonic wind-tunnel study of reducing the drag of a bluff body at incidence by means of a spike," by G. K. Hunt, RAE Rep. Aero 2606, May 1958. It is shown that the greatest drag reduction (50%) occurred at zero incidence and the spike became less effective as incidence increased. An evaluation of all of these experiments would be very useful.

I. I. Glass, Canada

**3481. Waldron, H. F., Flow properties behind strong shock waves in nitrogen, *J. Aero/Space Sci.* 25, 11, 719-720 (Readers' Forum), Nov. 1958.**

**3482. Carrier, G. F., Shock waves in a dusty gas, *J. Fluid Mech.* 4, 4, 376-382, Aug. 1958.**

When dust-laden gas passes through a stationary plane shock, the two phases reach common final temperature and velocity only after an interval in which the dust is decelerated and heated by the shocked gas. On basis of approximate treatment of momentum and heat transfer, this process is analyzed and formulated for numerical solution. Typical results are shown as graphs of gas velocity against dust velocity through the region of transfer.

S. Paterson, Scotland

**3483. Whitham, G. B., On the propagation of shock waves through regions of non-uniform area or flow, *J. Fluid Mech.* 4, 4, 337-360, Aug. 1958.**

Paper refers to work by Moeckel on interaction of oblique shock wave with shear layer in steady supersonic flow, and by Chester and Chisnell on propagation of shock wave down nonuniform tube. Equations of motion are written in characteristic form, and differential relation of flow to be satisfied at characteristic is applied to quantities just behind shock wave. Together with shock relations, this determines motion of shock wave. Author reports very good accuracy for wide range of cases.

Problems considered are: motion of wave down nonuniform channel or tube; propagation of shock through plane distribution of density, pressure, etc.; convergingly cylindrical or spherical shocks, including nonuniform states ahead of shock such as occur in magnetohydrodynamics; interaction of oblique shock inside entry of axisymmetrical supersonic duct; propagation of bore in water of nonuniform depth; motion of kinematic shock waves in traffic flow and flood waves when conditions downstream are non-uniform.

A. Balloffet, USA

**3484. Radhakrishnan, G., The exact flow behind a yawed conical shock, *Coll. Aero. Cranfield Rep.* 116, 22 pp. + 15 figs., Apr. 1958.**

The exact flow behind a yawed conical shock wave is investigated. A simple numerical method of solving the differential equations of motion behind the shock wave is evolved.

This method is applied to the case of the flow of a perfect gas behind a conical shock of semi-apex angle  $30^\circ$  yawed at  $20^\circ$  to a free stream of Mach number 10. The shape of the body which would produce such a shock wave is determined. The properties of the flow between the shock wave and the body surface are in-

investigated particularly with respect to the variation of entropy and the streamline pattern.

The existence of a singular generator on the body surface in the plane of yaw and on the "leeward" side, at which the entropy is many-valued, is brought out. It is found that, downstream of the shock, all stream lines curve round and tend to converge to this singular generator.

The body obtained by the present investigation is compared to the yawed circular cone which, according to Stone's first-order theory, would produce the same shock wave dealt with in this particular case. From author's summary by R. A. Gross, USA

**3485. Walkden, P., The shock pattern of a wing-body combination, far from the flight path, *Aero. Quart.* 9, 2, 164-194, May 1958.**

Position and strength of front shock wave at large distances from a wing-body combination are deduced by method of Whitham [AMR 6 (1953), Rev. 961 and 11 (1958), Rev. 918]. Body is body of revolution at zero angle-of-attack, wing may have thickness and be at angle-of-attack. Both steady and unsteady motion are considered, latter using method of Rao [AMR 10 (1957), Rev. 205]. Theory includes interference effects. In any lateral direction the far field is equivalent to that caused by a certain body of revolution. Some numerical results are given for a body with subsonic-leading-edge delta wing. Paper is of interest in connection with "supersonic bangs." A. E. Bryson, Jr., USA

**3486. Tsuge, S.-I., On a theory of shock waves in locally supersonic zone and a new boundary-value problem for Tricomi's equation, *J. Phys. Soc. Japan* 12, 12, 1412-1420, Dec. 1957.**

**3487. Naylor, D., Degenerate waves in unsteady gas flow, *J. Math. Mech.* 7, 5, 705-722, Sept. 1958.**

"Degenerate" flows have fewer dimensions in hodograph (velocity) space than in physical space. Important examples are Prandtl-Meyer flow, simple waves in transient rectilinear flow, Taylor-Maccoll flow, and Busemann's conical flows. More complex examples with less immediate practical application have been recently examined by author and by J. H. Giese.

This paper deals with unsteady, spatial, potential flows with hodographs reducing instantaneously to surfaces. These "double-waves" have velocity  $\vec{q} = \vec{q}(\lambda, \mu)$  where  $\lambda$  and  $\mu$  depend on  $x, y, z$ , and  $t$ . The sound speed  $a$  generally depends explicitly on  $t$  as well as  $\lambda$  and  $\mu$ . "Simple waves"  $\vec{q} = \vec{q}(\lambda)$ ,  $\lambda = (x, y, z, t)$  are also considered.

The analysis employs the Legendre transformation, which does not linearize the equations of motion in this case, but reduces independent variables from four to three. Sample results:

(1) For double waves, instantaneous curves of constant velocity are straight lines in physical space; for simple waves, velocity is instantaneously constant over planes.

(2) Instantaneous constant-velocity lines in double waves cannot be concurrent, hence no "centered" double waves exist in unsteady spatial flow. This supplements author's previous proof of nonexistence of centered simple waves in unsteady plane flow.

No sample flows are generated by the methods of the paper, nor are practical implications discussed.

F. S. Sherman, USA

**3488. Himmel, S. C., Application of the method of coordinate perturbation to unsteady duct flow, *NACA TM* 1439, 80 pp. + 4 tables + 4 figs., Sept. 1958.**

The method of coordinate perturbation (parametric representation of the independent and dependent variables of an unsteady duct flow in terms of characteristic network) is applied to the propagation of small disturbances in ducts and across shock waves which move along prescribed paths. Reasonable agreement with method of characteristics is obtained. L. Trilling, USA

## Boundary Layer

(See also Revs. 3506, 3549, 3578, 3582, 3584, 3590, 3600, 3603)

**3489. Sparrow, E. M., and Gregg, J. L., Viscous dissipation in low Prandtl number boundary-layer flow, *J. Aero/Space Sci.* 25, 11, 717-718 (Reader's Forum), Nov. 1958.**

Information supplementary to that given by Morgan Pipkin and Warner [AMR 11, (1958), Rev. 4723] on the adiabatic-wall problem is presented in the form of exact (numerical) solutions of the boundary-layer energy equation and of approximate solutions based on the Karman-Pohlhausen method. G. Power, England

**3490. Moore, F. K., The unsteady laminar boundary layer of a wedge and a related three-dimensional problem, *Heat Transf. and Fluid Mech. Inst., Calif. Inst. Technol., Pasadena, Calif.*, June 1957, 99-117.**

**3491. Meksyn, D., The boundary-layer equation for axially symmetric flow past a body of revolution—motion of a sphere, *J. Aero/Space Sci.* 25, 10, 631-634, 664, Oct. 1958.**

The method of integration which the author has developed for boundary-layer equations [AMR 4 (1951), Rev. 816 and AMR 5 (1952), Rev. 1830] is applied to the laminar boundary layer on the surface of the axially symmetrical bodies. The partial differential equation of the flow in the boundary layer is reduced to a simpler equation which is then integrated asymptotically. The frictional force and the separation point of the boundary layer are computed.

Using this method, the boundary layer on the surface of a sphere is computed. The results are compared with the known measurements by Fage (1937). M. Strscheletsky, Germany

**3492. Nickel, K., Some properties of the solutions of the Prandtl boundary layer equations (in German), *Arch. Rational Mech. Analysis* 2, 1, 1-31, Sept. 1958.**

Papers about boundary-layer theory always deal with the problem of finding out solutions of the boundary-layer differential equations for given outlines and boundary conditions and developing suitable calculation methods. On the other hand there has existed up to now no investigations of the properties of solutions only on the basis of the structure of the boundary-layer differential equations. To such a theory of the boundary-layer differential equations the presented paper is dedicated.

By reason of a theorem of M. Nagumo and H. Westphal, which is proved once more for the case in question, general predictions about the character of the solutions can be made. It is shown in which way a given boundary-layer profile is developing downstream and which developments are impossible. Especially for a two-dimensional incompressible stationary laminar boundary layer along an impermeable wall with nonrotating outer flow the following is proved: (a) Supercritical velocities cannot originate or grow, if existing; (b) shearing stress gets its minimum and maximum values at the initial profile and at the wall; (c) for decelerated flow separation is not possible; (d) for a given outer flow  $U(x)$  the whole boundary layer is uniquely defined by the initial profile.

K. Gersten, Germany

**3493. Kueth, A. M., On the stability of flow in the boundary layer near the nose of a blunt body, *Rand Corp. RM-1972 (ASTIA AD 150 687)*, 13 pp., Aug. 1957.**

An approximate analysis of the stability of flow in the boundary layer near the nose of a blunt body shows that the destabilizing influences of stretching of vortex filament and of surface cooling on the flow over a convex surface exceed the stabilizing influence of curvature up to a certain distance from the nose.

From author's summary by S. I. Pai, USA

3494. Landweber, L., and Siao, T. T., Comparison of two analyses of boundary-layer data on a flat plate, *J. Ship Res.* 1, 4, 21-33, Mar. 1958.

A set of measurements of the mean velocity in the turbulent boundary layer with zero pressure gradient on a flat plate, obtained in the wind tunnel at the Iowa Institute of Hydraulic Research using Preston's calibrated stagnation tube, is presented and analyzed. The analysis is made in two ways, first according to the logarithmic law and then according to the power-law generalization suggested by Townsend. The predictions according to the two laws agree well for Reynolds numbers less than  $10^6$ , but deviate significantly at higher values. Schoenherr's theoretical curve is in excellent agreement with the data and the logarithmic law for Reynolds numbers greater than  $2 \times 10^6$ , but is too low for lower values.

R. P. Pearce, Scotland

3495. Bradfield, W. S., An experimental investigation of the turbulent boundary layer in supersonic flow around yawed cones with small heat transfer and correlations with two dimensional data, Convair Scient. Res. Lab., Res. Rept. 1, 71 pp. + 3 tables + 5 appendixes + 29 figs., Mar. 1958.

Experimental work in the turbulent boundary layer in essentially adiabatic flow at supersonic speeds may be loosely divided into five main categories: experiments on flat plates; on cones; two-dimensional flows with pressure gradients; three-dimensional flows with pressure gradients; and, flows with surface temperature gradients. The present work concerns itself with the second of these categories; namely, cone flow. The essence of the present work is the comparison by suitable engineering relations of cone flow experiments under constant surface temperature and nearly adiabatic flow with corresponding plate flow experiments, both compressible ( $1 < M_\infty < 5$ ) and incompressible.

In pursuit of this end, a new type of total temperature boundary-layer probe was designed, developed, and applied to the first measurements of total temperature profiles in the boundary layer of a cone at supersonic speeds; a qualitative, integrated, physical picture of probe-boundary-layer interactions was developed; correlations among velocity profiles, total temperature profiles, momentum thickness, displacement thickness, shape parameter and enthalpy increment for plate, cone, and axial flow cylinder were established; and local values of heat-transfer and skin-friction coefficients were compared with compressible and incompressible flow plate values.

The result is that the engineer, knowing an incompressible relation for skin friction, a reference temperature defined by Eckert, the modified Reynolds analogy of Colburn, and the plate-to-cone transformation of the present work, can readily predict skin-friction and heat-transfer values in a turbulent boundary layer on a conical body in-flight at zero yaw.

From author's summary

3496. Pozzi, A., Application of integral methods to the study of the laminar motion of non-reacting binary gas mixtures (in Italian), *Aerotecnica* 37, 6, 311-320, Dec. 1957.

Two examples of steady two-dimensional boundary-layer flows of a nonreactive mixture of two fluids are considered. The first is the boundary-layer flow over a flat plate with injection of a second fluid through a finite portion of the plate. The second is the resulting interaction of two parallel streams of different fluids which previously have been flowing on opposite sides of a finite thin wall (and over which each has been forming its own boundary layer). Karman integral methods with Pohlhausen-type polynomial expansions for velocity, concentration, and enthalpy profiles are used to satisfy the integral form of the equations. Numerical results and comparison with known exact solutions are promised in a subsequent paper.

P. Chiarulli, USA

3497. Kalikhman, L. E., Equations for the turbulent boundary layer in a gas, transformed to ordinary linear differential equations and solved in finite form, *Dokladi Akad. Nauk SSSR (N.S.)* 106, 3, p. 401, Jan. 1956.

3498. Struminskii, V. V., Equations of the three dimensional boundary layer in a compressible gas for an arbitrary surface (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 114, 2, 271-274, 1957 (Translation by M. D. Friedman, Inc., 67 Reservoir St., Needham Heights 94, Mass., S-128, 6 pp.)

3499. Plan, M., Methods of the dynamic and thermal investigation of laminar compressible boundary layer on a plane surface (in French), *Publ. Sci. Tech. Min. Air, France* no. 331, v + 123 pp., 1957.

First part of the article gives a general review about the physical properties of a compressible viscous fluid and about the different methods for calculating the laminar compressible boundary layer, including simplifications and additional assumptions.

In the second part complete and systematic experimental investigations of the compressible laminar boundary layer along a flat plate at supersonic speeds are presented. It is shown by means of systematic experiments in which way velocity profiles and temperature profiles can be measured practically and how errors effected by the probes can be corrected. It is found that circular probes are more useful than the flattened probes generally used. If the local frictional coefficients are to be found by determining the slope of the velocity profile at the wall, probes with diameters of 0.08 mm must be used. But the time needed for measurements by those small probes is very great (3 hours for one velocity profile).

Finally, the influence of the finite thickness of the leading edge of the plate on the development of the shock wave and the flow near the leading edge is investigated and an estimation of the additional losses, generated by this thickness effect, is given.

K. Gersten, Germany

3500. Wilkins, M. E., and Darsow, J. F., Finishing and inspection of model surfaces for boundary-layer-transition tests, *NASA Memo.* 1-19-59A, 10 pp. + 6 figs., Feb. 1959.

Techniques which have been used for finishing and quantitatively specifying surface roughness on boundary-layer-transition models are reviewed. The appearance of a surface as far as roughness is concerned can be misleading when viewed either by the eye or with the aid of a microscope. The multiple-beam interferometer and the wire shadow method provide the best simple means of obtaining quantitative measurements.

From authors' summary

3501. Jack, J. R., and Wisniewski, R. J., The effect of extreme cooling and local conditions on boundary-layer transition, *J. Aero/Space Sci.* 25, 9, 592-593 (Readers' Forum), Sept. 1958.

3502. Pivko, S., On the effect of flow separation on the lift of slender bodies, *J. Roy. Aero. Soc.* 62, 575, 832-833, Nov. 1958.

3503. Rakhmanovich, A. N., The boundary layer at a surface of large, longitudinal curvature (in Russian), *Trudi Ufimsk. Aviat. Inst.* no. 2, 3-22, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9037.

Investigations of the boundary-layer conditions in curvilinear channels embraced the following questions: (1) The order of magnitude of the transverse pressure gradient in the boundary layer; (2) methods of determining the thickness of the boundary layer; (3) methods of calculating the nominal thickness; (4) the accuracy of the usual methods for determining the velocity profile in the boundary layer.

The investigations were made on a two-dimensional blade cascade with a curvature of  $89^\circ$  of the profile center line. The experiments were conducted in conditions corresponding to  $M = 0.3$ ,

and  $R = 3.43 \times 10^4$ . As a result of the investigation, it was found that the transverse gradient in the boundary layer is of the same order as in the principal flow. In a nonrectilinear flow of considerable curvature, the velocity profile in the boundary layer should be determined from the results of dynamic pressure measurements. In the case of a flow around a convex surface, the boundary layer contains flow regions with positive and negative transverse velocity gradients; in the case of a concave flow surface, the velocity gradient does not change sign.

The thickness of the boundary layer in a nonrectilinear flow of considerable curvature can be determined from the distance  $\delta$  from the surface of the body, on which the viscosity is controlled by the reduction in quantity of motion of unit mass, by 0.01 of the corresponding value in the main flow. Expressions are given for determining the nominal thicknesses in the curvilinear flow of an incompressible fluid, from which the known expressions for a rectilinear flow can be derived as a particular case.

N. N. Shirokov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

## Turbulence

(See also Revs. 3494, 3497, 3602, 3608)

**3504. Ogura, Y., Temperature fluctuations in an isotropic turbulent flow, *J. Meteorol.* 15, 6, 539-546, Dec. 1958.**

Author employs methods of Heisenberg to deduce the power spectrum for temperature fluctuations in stationary isotropic turbulence assuming independence of temperature and velocity fluctuations. For intermediate and highest wave number ranges, the  $-5/3$  and  $-7$  power variations, respectively, (as previously deduced by Corrsin) are obtained as special cases of the present theory. By employing an approximate interpolation formula for the power spectrum, author derives an autocorrelation function which compares quite satisfactorily with observed autocorrelations by Shiotani for time lags less than 2 seconds. Some inferences are also made in respect to the size of smallest eddies.

R. O. Reid, USA

**3505. Al'tshul', A. D., Velocity distribution in a turbulent flow of fluid in industrial pipes (in Russian), *Teploenergetika* 3, 2, 47-50, Feb. 1956.**

**3506. Fenter, F. W., and Stalmach, C. J., Jr., The measurement of turbulent-boundary-layer shear stress by means of surface impact-pressure probes, *J. Aero/Space Sci.* 25, 12, 793-794 (Readers' Forum), Dec. 1958.**

**3507. Barat, M., Influence of the turbulence upon values of static pressure measurements (in French), *C. R. Acad. Sci. Paris* 246, 8, 1156-1158, Feb. 1958.**

Using the formula of Goldstein:  $p_m = p_s + k\rho(v^2 + w^2)$  ( $p_m$  pressure measured by a pitot tube,  $p_s$  real pressure,  $v$ ,  $w$  transverse velocity fluctuations,  $\rho$  density of fluid,  $k$  correction factor) for the measurement of the static pressure in turbulent flows by means of a pitot tube, author distinguishes the three different cases:  $D > L$  with  $0 < k < 1/6$ ,  $D < \lambda$  with  $k < 0$ ,  $\lambda < D < L$  with  $k$  positive or negative according to the distribution of the vortices ( $D$  tube diameter,  $L$  scale,  $\lambda$  microscale).

Margot Herbeck, Germany

**3508. Ershin, Sh. A., The aerodynamics of a turbulent gas torch (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk., In-ta Energ. Akad. Nauk KazSSR, Alma-Ata, 1957; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9136.**

## Aerodynamics

(See also Revs. 3201, 3450, 3452, 3485, 3541, 3638, 3658)

**3509. Truckenbrodt, E., On the transition from the extended to the simple lifting line theory for oblique and swept wings (in German), *Z. Flugwiss.* 5, 9, 259-264, Sept. 1957.**

The fundamental ideas of the extended (Weissinger three-quarter-chord point method) and simple (Prandtl) lifting-line theories are reviewed and compared. It is shown that the simple theory can be obtained from the extended theory by an appropriate asymptotic representation. These ideas are carried over to the cases of oblique and swept wings for which the simple theory is not applicable, and a simplified form of the extended theory is presented. It is shown that the results are in satisfactory agreement with those given by the exact form of the extended theory.

J. R. Spreiter, USA

**3510. Licher, R. M., Minimum drag at supersonic speeds for cylindrical ring wings of specified volume or base area at zero lift, Douglas Aircr. Co. Rep. SM-22995, 19 pp., Nov. 1957.**

Given a circular ring wing of constant chord which is required to contain a specified volume, the problem is to find the least wave drag possible when the volume is distributed in the optimum way. It is also desired to determine how the minimum drag value can be reduced by properly cambering the wing to take advantage of the interference between thickness and radial force in the nonplanar configuration. A second problem is to find the minimum wave drag on the ring wing with fixed base area.

For spatial configurations there is generally some interference between distribution of volume and distribution of force. For the first problem considered in this report (the optimum distribution of thickness for given volume), the minimum drag values are obtained for cases with no radial force and with the optimum radial force. But for the case of the ring wing with the optimum distribution of thickness for a given base area, there is no interference between the thickness distribution and any radial forces, so only a single optimum is found.

From author's summary by T. Riahokin, USA

**3511. Nicholson, K. F., The effects of blunt leading edges on delta wings at Mach 5.8, *J. Aero./Space Sci.* 25, 12, 786-787 (Readers' Forum), Dec. 1958.**

**3512. Antselyovich, L. L., The design of a delta-wing, high-speed aircraft (in Russian), *Trudi Mosk. Aviat. In-ta* no. 64, 5-14, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8787.**

On the basis of published information the aerodynamic and structural characteristics of the delta wing are discussed with particular regard to the general design of a delta-wing aircraft.

The delta wing is free from the disadvantages of the swept wing in regard to weight, rigidity and low efficiency of the mechanical equipment, and at the same time can be given a relatively small thickness (3-6%); it shares these properties with all low-aspect-ratio wings.

The physical picture of the flow around a delta wing is examined, its three-dimensional character is noted, leading to appearance of maximum suction areas at the root, instead of near the tip, as in the case of swept wings of customary aspect ratio. Although complete breakaway of the flow occurs at angles of incidence of the order of  $40^\circ$ , a partial breakaway can take place at  $10-15^\circ$  incidence. Partial breakaway decreases the value of the derivative of the lift coefficient by the angle of incidence, and influences the stability and maneuverability of the aircraft.

It is noted that the transverse and hunting stability of an aircraft are enhanced for the delta wing, in the presence of high lift and low damping. Considerations of rigidity and strength make it inad-

visible to use a monospar system for the wing structure. Phenoplastics are suitable as skin reinforcement.

The author considers a middle-wing arrangement to be the best.

The advantages and disadvantages of a tailless construction with horizontal control surfaces are indicated, without giving any relevant conclusions.

G. S. Aronin

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3513. Yoshihara, H., and Strand, T., On Jones' criterion for optimum lifting wings, *J. Aero/Space Sci.* 25, 9, p. 600 (Readers' Forum), Sept. 1958.**

**3514. Smith, J. H. B., Calculation of the shape of a thin slender wing for a given load distribution and planform, *Aero. Res. Council. Lond. Curr. Pap.* 385, 16 pp. + 8 figs. 1958.**

By use of slender-wing theory the local surface-slope distribution required to produce a rectangular spanwise lift distribution, together with a two-dimensional flat-plate chordwise pressure distribution, was calculated for swept tapered wings. As would be expected, the angle-of-attack distribution obtained in this way is infinite at the wing tips and the centerline, but is otherwise continuous. The problem is said to be of interest in connection with design of a wind-tunnel model.

M. T. Landahl, Sweden

**3515. Chaudhuri, S. N., and Nagaraja, K. S., Determination of distribution of twist of a straight wing to correspond to the aerodynamic-load distribution on a sweptback wing, *J. Aero/Space Sci.* 25, 9, 593-594 (Readers' Forum), Sept. 1958.**

**3516. Kaufmann, W., The concept of the curled-up vortex sheet generated behind an airfoil (in German), *Z. Flugwiss.* 5, 11, 327-331, Nov. 1957.**

The concept of the curled-up vortex sheet, generated behind an airfoil, is based on the assumption of an inviscid fluid, and the two separate vortices, into which the vortex sheet has finally rolled up, are considered to be potential vortices. With this idealization the distance between the two separate vortices can be calculated in the usual manner. However, all the measurements which are available have shown the distance between the vortices, as obtained from theory, to be smaller than that found by experiment. In the present paper, the two idealizations have been neglected in order to derive an explanation for the discrepancy existing between theory and experiment.

From author's summary

**3517. Scherer, M., Delaveault, P., and Riou, F., Determination of aerodynamic derivatives in flight and the efficiency of control surfaces of an airplane from the responses to harmonic forcing functions applied by the pilot (in French), 9th Congrès Intern. Mécan. Appl., 1957; 2, 517-526.**

Authors suggest flight test technique for determining airplane stability derivatives. The pilot applies periodic forcing function to each control surface in turn and the responses are measured. Linearized stability equations are then solved for the stability derivatives. Comparison with wind-tunnel model tests appears to be satisfactory.

T. R. Goodman, USA

**Book—3518. Vetchinkin, V. P., Selected works, Vol. I; Aircraft dynamics (in Russian), Moscow, Izd-vo Akad. Nauk SSSR, 1956, 422 pp. + illus.; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8795.**

The selected works of V. P. Vetchinkin are published in two volumes. The first volume includes papers on the mechanics of aircraft flight; the principal being one on "Aircraft Dynamics".

Even though this monograph discusses the flight of piston-engined aircraft with an airscrew, it is in method of presentation a fundamental guide to further scientific research in the sphere of the flight mechanics of reaction-propelled aircraft.

The first chapter communicates data on the pressure, temperature and density of the atmosphere at altitudes up to 150 kilometres.

The second chapter gives fundamental information on the aerodynamic forces acting on an aircraft. Two similarity standards are examined: wing incidence, and the Reynolds number.

The third chapter investigates the motion of an aircraft on and near the ground (take off and landing in horizontal flight).

The fourth chapter examines the gliding flight of an aircraft. Solution of the differential equations of motion is carried as far as the quadratures, by numerical calculation.

The fifth chapter is devoted to the theory of action of various undercarriage shock-absorbers: pneumatic, rubber, spring, liquid (hydraulic) and combined systems. The tail-wheel undercarriage is that particularly examined.

Great methodological interest is presented by the sixth chapter, which discusses flight in the vertical plane (climbing and diving flight). The presentation is on the assumption that the air density is invariable in altitude. This chapter is highly instructive with regard to the methods of numerical integration of the differential equations of motion, which it contains.

The seventh chapter exposes the theory of curvilinear flight (without sideslip) and spiral gliding, including the problem of manoeuvrability in such conditions of flight.

The eighth chapter discusses the decrease in weight of an aircraft in rectilinear, uniform, descending flight, and gives a solution for the problem of least fuel consumption.

The ninth chapter contains solutions for some problems on diving calculations in the presence of decreasing air density with altitude, flight paths for aerial reconnaissance over the maximum area in the presence of wind, etc.

This first volume of the collected works also includes V. P. Vetchinkin's papers on the dynamics of jet flight. In particular, a number of problems are presented regarding the dynamics of the jet aircraft. These take into consideration the curvature of the Earth, variability of the air density with height, and change in weight of the aircraft. It further contains papers on the dynamics of the vertical motion of an aircraft, projectile or rocket, of variable mass, and the flight of a finned rocket at supersonic speed. The latter contains, in particular, some information on the aerodynamics of an airfoil at supersonic speeds.

The first volume closes with a paper on the longitudinal oscillations and longitudinal dynamic stability of an aircraft. This was read in 1953 before the III All-Soviet Congress on Aerodynamics, and was published in the Transactions of the Congress.

L. V. Klimenko

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3519. Thompson, W. E., and Horne, W. B., Low-speed yawed-rolling characteristics of a pair of 56-inch-diameter, 32-ply-rating, type VII aircraft tires, *NASA Memo.* 2-7-59L, 10 pp. + 2 tables + 12 figs., Feb. 1959.**

The low-speed cornering characteristics of the tires under straight-yawed rolling were determined over a range of inflation pressures and yaw angles for a vertical load approximately equal to 75% of the rated vertical load. The quantities measured or determined included cornering force, drag force, self-aligning torque, pneumatic caster, vertical tire deflection, yaw angle, and relaxation length.

From authors' summary

**3520. Newsom, W. A., Jr., and Tosti, L. P., Force-test investigation of the stability and control characteristics of a 1/4-scale model of a tilt-wing vertical-take-off-and-landing aircraft, *NASA Mem.* 11-3-58L, 7 pp. + 2 tables + 14 figs., Jan. 1959.**

The model had two propellers with hinged (flapping) blades mounted on the wing which could be tilted from 4° incidence for forward flight to 86° for hovering flight. The investigation in-

cluded measurements of both the longitudinal and lateral stability and control characteristics in both the forward flight and transition ranges. Tests in the forward flight condition were made for several values of thrust coefficient, and tests in the transition range were made at several values of wing incidence with the power varied to cover a range of flight conditions from forward acceleration (or climb) conditions to deceleration (or descent) conditions. The data are presented without analysis.

From authors' summary

**3521. Tosti, L. P., Flight investigation of the stability and control characteristics of a 1/4-scale model of a tilt-wing vertical-take-off-and-landing aircraft, NASA Memo. 11-4-58L, 12 pp. + 2 tables + 3 figs., Jan. 1959.**

The model had two propellers with hinged (flapping) blades mounted on the wing which could be tilted up to an incidence angle of nearly  $90^\circ$  for vertical take-off and landing. The model had conventional aileron, rudder, and elevator controls for forward flight. For hovering flight, jets at the tail provided pitch and yaw control, and differential total pitch of the propellers provided roll control. The investigation consisted of hovering flights in still air, vertical take-offs and landings, and slow constant-altitude transitions from hovering to forward flight.

From author's summary

**3522. Williams, J. L., and DiCamillo, R. J., Effects of fuselage nose length and a canopy on the low-speed oscillatory yawing derivatives of a swept-wing airplane model with a fuselage of circular cross section, NASA Memo. 1-15-59L, 8 pp. + 3 tables + 9 figs., Jan. 1959.**

Data were obtained at various frequencies and amplitudes for angles of attack from  $0^\circ$  to about  $32^\circ$ . Static lateral and longitudinal stability data are also presented. The data were obtained at a Mach number of 0.13 and a Reynolds number of about  $0.83 \times 10^6$ .

From authors' summary

**3523. Hirsch, R., Determination of the lift on an airfoil equipped with a slot jet at the trailing edge and correction for finite span (in French), Publ. Scient. Tech. Min. Air, France NT 69, 75 pp., Oct. 1957.**

A method is presented for calculating the lift on an airfoil with a jet of air issuing from a slot near the trailing edge. The lift is computed by considering the circulation induced by the trailing vorticity set up by the jet. The viscous dissipation of vorticity is taken into account, with the boundary condition of no circulation far downstream. This viscosity correction lowers the circulation (and lift) slightly below the classical Joukowski value in the case of zero jet velocity. Calculations predict substantial lift due to blowing near the trailing edge. Experiments confirm these predictions.

The method is applicable to wings with camber and with full-span flaps. By consideration of the downwash due to tip vortices, lift on wings of finite span is computed. The wing-body case is also investigated. The method is developed only for incompressible flow.

L. H. Schindel, USA

**3524. Spence, D. A., Some simple results for two-dimensional jet-flap aerofoils, Aero. Quart. 9, 4, 395-406, Nov. 1958.**

Approximate expressions for the lift coefficient and pressure distribution are obtained for a thin two-dimensional wing at zero incidence to a uniform stream of incompressible inviscid fluid with a narrow high-velocity jet of small momentum coefficient issuing from the trailing edge at small downward inclination. Numerical results indicate good agreement with experiment. Interpolation formulas are suggested for larger values of the momentum coefficient based on the results of AMR 10 (1957), Rev. 2218.

E. E. Jones, England

## Vibration and Wave Motions in Fluids

(See also Revs. 3483, 3581, 3596)

**3525. Lysanov, Iu. P., Theory of the scattering of waves at periodically uneven surfaces, Soviet Phys.-Acoustics 4, 1, 1-10, Oct. 1958. [Translation of Akust. Zh. 4, 1, 3-12, Jan./Mar. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.]**

Author has written a brief review that summarizes the methods of approach to this difficult problem. Especially notable is a bibliography of 79 items. This review will be of value to the casual as well as the intensely interested worker.

M. Harrison, USA

## Fluid Machinery

(See also Revs. 3203, 3204, 3328, 3385, 3437, 3467, 3559, 3639)

**3526. Yurkevskii, S. V., Determination of the feed coefficient of a piston compressor (in Azerb.), Trudi Azerb. N.-i. In-ta Mashinostr. no. 1, 143-155, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 11470.**

An analysis is furnished of the working cycle of a piston compressor and recommendations made regarding basic factors reducing the compressor feed—lowering the pressure and increasing the air temperature when being sucked in. The proposals regarding the heating of the air are the outcome of experimental data obtained in investigations on a number of industrially accepted compressors.

G. A. Varshavskii

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3527. Huber, R., Present state and future outlook of the free-piston engine, Trans. ASME 80, 8, 1779-1790, Nov. 1958.**

**3528. Isay, W.-H., Calculation of flow through axial cascade of airfoils (in German), ZAMM 37, 9/10, 321-335, Sept./Oct. 1957.**

Paper contains numerical examples illustrating author's theory presented in article "Beitrag zur Potentialstromung durch axiale Schaufelgitter," ZAMM 33, p. 397, (1955), reviewed in AMR 7 (1954), Rev. 3621. The theory of that paper is developed further, and the formulas are elaborated for the purposes of numerical computation.

A. H. Shapiro, USA

**3529. Scholz, N., Considerations on the influence of compressibility on the flow past a cascade of airfoils (in German), Z. Flugwiss. 5, 9, 265-269, Sept. 1957.**

The relations between the quantities of the inflow and the outflow are considered for a two-dimensional compressible cascade flow. The exact equations are given together with the linearized relations for small Mach numbers. Using two universal diagrams, the calculation can be reduced to the unambiguous and simple case of the incompressible cascade flow.

From the author's summary by J. R. Spreiter, USA

**3530. Kostychev, G. I., Calculation for hydrodynamic lattices (in Russian), Trudi Kazansk. Aviats. In-ta 31, 23-36, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 11544.**

The author determines expressions for the coefficients, comprised in the function which conformally reflects the outward appearance of a lattice made of arbitrary profiles on to the outside of a series of concentric rings in an infinitely foliated stretched surface through the coefficients of the normal parametric presentation of the profile. The relations can be expressed at any degree of exactness.

I. S. Simonov

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3531. Tsuji, S., Study on surge-prevention of blower, *Bull. JSME* 1, 2, 156-161, June 1958.**

Author develops stability equation for blower system using the theory of small oscillations and verified the analysis by automatic controlled surge-prevention experiments. Author concludes suppression method used is more effective than others because: (1) energy loss is small, (2) apparatus is simple, and (3) high stability is obtained.

J. C. Geyer, USA

**3532. Shirakura, M., An approximate method of determining the slip factor of the radial outward-flow impellers, *Bull. JSME* 1, 2, 171-178, June 1958.**

Approximate method of determining velocity distribution along blades is developed and checked against theoretical distribution for logarithmically spiral blades. Author states method is therefore suitable for any radial outflow impeller. Pressure distribution, torque on fluid and slip factor can then be derived. Method, which was experimentally verified, is especially useful for pump impellers with closely spaced blades.

J. C. Geyer, USA

**3533. Kussoy, M. I., and Bachkin, D., Performance of typical rear-stage axial-flow compressor rotor blade row at three different blade setting angles, *NASA Memo.* 11-27-58E, 12 pp. + 2 tables + 15 figs., Jan. 1959.**

A comparison of the performance of a single-stage rotor run at three setting angles covering a  $30^\circ$  range is presented. The results indicate higher peak pressure ratios and greater maximum equivalent weight flows for the lower setting angles at all speeds tested. During part-speed operation, the efficiencies were higher for the lower setting angles and the flow ranges were about the same for all three setting angles. However, near maximum speed, the flow range was noticeably less for the lowest setting angle, while the efficiencies were about the same for each configuration.

From authors' summary

**3534. Wilcox, W. W., Tysl, E. R., and Hartmann, M. J., Resume of the supersonic-compressor research at NACA Lewis Laboratory, *ASME Ann. Meet.*, New York, N. Y., Nov./Dec. 1958. Pap. 58-A-177, 10 pp.**

**3535. Horlock, J. M., A rapid method for calculating the "off-design" performance of compressors and turbines, *Aero. Quart.* 9, 4, 346-360, Nov. 1958.**

The method is based on a suggestion by Mellor of splitting the machine into an infinite number of stages, each producing a small change in stagnation temperature. For a compressor, assuming a constant polytropic efficiency, the results give linear characteristics approximating fairly well the actual characteristics of a typical compressor. Introducing a correlation of varying polytropic efficiency with pressure and flow coefficient yields curved characteristics which show good agreement with actual results except at low speeds. For a turbine, the method yields results very close to the common Stodola ellipse law.

The advantage of the method lies in the ease and rapidity with which the off-design performance may be approximated, not requiring the use of a computer and being generally adequate for preliminary design studies. The method does not predict surge points and is not accurate where stalling may occur.

D. G. Shepherd, USA

**3536. Kondryakov, I. K., and Bazovskii, V. N., Calculations for a system of transmission of the reversing motion of the drum of an indicator for recording a rotating compressor fitted with plates (in Russian), *Sb. Tr. Obshchestven. Kafedr. Leningr. Tekhnol. In-ta Kholodifn. Prom-sti* 12, 211-222, 1956; *Ref. Zh. Mekh.* no. 10, 1957. Rev. 11468.**

It is noted that the moving system of the drum of the indicator when recording rotating compressors, based on the principle of a

cam gear transmission with a supplementary reverse spring, has the defect of possibly distorting the recorded indicator diagram. At the same time an investigation was made of the cam gear transmission without the reverse spring, but which effects the reverse motion of the indicator drum, also by means of a spring, but disposed in the indicator drum itself. A modified plan is put forward illustrating the transmission of motion from the compressor shaft to the indicator drum. Points are discussed connected with the calculation of the geometrical parameters of the transmission components being investigated. A solution is given in full of the problem in a general case regarding the selection of the working profile of the cam gear. The assertion is made that the system of transmission examined should ensure an even recording on the abscissa axis of the indicator diagram.

G. E. Khudyakov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3537. Sakun, I. A., Selection of the extent of internal compression of a screw compressor (in Russian), *Trudi Leningr. Voen.-Mekhan. In-ta* no. 3, 74-79, 1955; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11469.**

The conditions are investigated of the operation of a screw compressor, working in unknown regimes, when the pressure of internal compression  $p_a$  is not equal to the pressure in the network of delivery (force)  $p_H$ . In order to ascertain the magnitude of the relative thermodynamic losses in the working of the compressor in unknown regimes the author introduces the concept of the coefficient of increase of the theoretical work  $K_{ur}$ , showing by how many times the theoretical work of compression of the unit volume of gas in an unknown regime is greater than the theoretical work of compression in a basic regime, that is when  $p_H = p_a$ . The expression obtained for the coefficient of increase in the theoretical work does not take into account the gaseous dynamic loss in the compressor, nor leakage and other losses. In the basic regime  $K_{ur}$  equals 1, in all other cases  $K_{ur} > 1$ . The deduction is made that the work of the compressor in regimes where the forcing pressure is not equal to the pressure of internal compression is less economical than in the basic regime, when these pressures coincide. It is shown, on the basis of the analysis of the expression for  $K_{ur}$ , that an important property of the screw compressor, with an uncontrolled degree of internal compression, is its optimum economy in operation over a comparatively wide range of force-pressure changes and the fact that this range widens with the raising of the degree of internal compression.

A. S. Ginevskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**Book—3538. Zhuchenko, M. M., and Ivanov, V. M., Ship propellers (in Russian), Leningrad, Sudopromgiz, 1956, 344 pp. + illus.; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8985.**

**3539. Tachminidji, A. J., The potential problem of the optimum propeller with finite number of blades operating in a cylindrical duct, *David W. Taylor Model Basin Rep.* 1228, 25 pp., July 1958.**

The increasing use of screw propellers operating in nozzles requires a thorough knowledge of the effects of such fixed boundaries on propeller efficiency. The present theoretical investigation, following those made by Wood and Harris and by Goodman, will be useful for a better understanding of the problem. The analysis is conducted for a propeller with minimum energy loss operating in a circular duct of constant diameter and of infinite or semi-infinite length. Using Bessel functions, author gives numerical results for specific cases, such as decreasing number of blades and a range of propeller-duct diameter ratios.

R. Spronck, Belgium

**3540. Kondrat, K. I., An approximate method for calculating the induced velocities of the free vortices of an airscrew with non-**

**radial blades** (in Russian), *Trud' Leningrad In-ta Aviats. Priborost.* no. 13, 21-40, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8775.

In the case of nonradial blades whose axes are arranged along a helix (author calls them "rational"), the calculation of the induced velocity of the free vortices is reduced to calculating the incremental velocities induced by the regions of the propeller vortices situated between the blade axis and a particular mean radial straight line.

To calculate the incremental velocity, author uses the expansions already used by N. N. Polyakhov, as well as an exponential expansion of  $\sin \vartheta$ ,  $\cos \vartheta$  by powers of  $\vartheta$ .

Considering that the essential component of the induced velocity is represented by the first terms of the expansion, representing the velocity for a screw with an infinite number of blades, author also restricts calculation of the incremental velocities to these first terms.

*Abstractor's Note:* It should be mentioned that in actual fact, with propeller advance/diameter ratios exceeding unity, the induced velocity exceeds many times the velocity for a propeller with infinite blade number (mean peripheral velocity), particularly in the end section of the blade; consequently, it is hardly possible to restrict calculation to the first terms of the expansions. In addition, since the author is in any case obliged to resort to resolution of  $\sin \vartheta$ ,  $\cos \vartheta$  by powers of  $\vartheta$ , it will be simpler and more accurate to apply these resolutions (expansions) immediately, and not use the expansions of N. N. Polyakhov.

G. I. Maikapar

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3541. Churchill, G. B., and Harrington, R. D., Parasite-drag measurements of five helicopter rotor hubs, NASA Memo. 1-31-59L, 7 pp. + 2 tables + 13 figs., Feb. 1959.**

The results indicate that, within the range of the tests, changes in angle of attack, hub rotational speed, and forward speed generally had only a small effect on the equivalent flat-plate area representing parasite drag. The drag coefficients of the basic hubs, based on projected hub frontal area, increased with hub area and varied from 0.5 to 0.76 for the hubs tested.

From authors' summary

**3542. Dusenberre, G. M., A note on propulsion efficiency, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-245, 4 pp.**

## Flow and Flight Test Techniques and Measurements

(See also Revs. 3480, 3495, 3517, 3582, 3685)

**3543. Patterson, G. D., Jr., and Rabouin, L. H., III, Capillary viscometer for high-temperature measurements of polymer solutions, Rev. Sci. Instrum. 29, 12, 1086-1088, Dec. 1958.**

An all-glass capillary viscometer is described which permits dissolving polymers at high temperatures, filtering, and measuring the solvent and solution efflux flow times without removal from a vapor bath. The advantages include safe handling of liquids at high temperatures without the precipitation or oxidative-degradation difficulties normally encountered in other methods of measuring polymer solution viscosities at elevated temperatures.

From authors' summary

**3544. Hills, J. F., A rotational viscometer employing a reference liquid, J. Sci. Instrum. 35, 11, 415-418, Nov. 1958.**

The viscometer described is a rotational one in which a free rotor is accelerated by the torque transmitted through a reference liquid by a driven rotor, and retarded by the torque acting through

the liquid under test which is restrained by a stator. The free rotor thus attains an equilibrium speed of rotation. The ratio of the rates of rotation of the driven and free rotors is a linear function of the viscosity being measured, and, apart from a negligible effect of bearing friction, is independent of the absolute rotational speed of the driven rotor when using Newtonian liquids.

The theory of the viscometer is given together with an account of an experimental verification. A discussion of the practical application of the instrument includes a study of the accuracy obtainable, and it is shown that with one instrument a viscosity range of 1000:1 may be obtained for which the maximum error does not exceed approximately  $\pm 0.5\%$  of the measured viscosity for a single test. For error limits of  $\pm 0.2\%$  the range is 30:1.

A feature of the viscometer is that it readily lends itself to the provision of a simple digital "read-out" in any required units.

From author's summary

**3545. Weingart, F., Measurement of pressure by the condenser-microphone method (in Hungarian), Meres es Automat. 6, 7/8, 233-234, 1958.**

A condenser-type pressure-transmitter for wide pressure ranges and having a simple circuit has been developed for recording with an oscillograph. Article describes the device, the circuit of the electronic amplifier and converter, the measuring experiences, as well as the characteristics of the measuring instrument.

From author's summary

**3546. Pavlov, V. P., The investigation of the viscosities of disperse systems by means of a twin rotary viscometer (in Russian), Trud' 3-i Vses Konferentsii po Kolloid Khimii, 1953; Moscow, Akad. Nauk SSSR, 1956, 144-154; Ref. Zh. Mekh. no. 8, 1957, Rev. 9239.**

A twin rotary viscometer is described by which the relationship between the frictional stress and the rate of shear of a number of dispersions has been determined. The two internal cylinders of the viscometer are of identical diameter (38 mm), but of different length (40 and 90 mm), and are linked by gear wheels through which the drive is taken from an electric motor with a hydraulic clutch; this enables the speed of rotation of the cylinders to be continuously varied between 3 and 1500 rpm. The internal cylinders of the viscometer are fitted in identical ball bearings and enclosed in outer cylinders with a clearance of 0.25 mm.

The frictional moment in the viscometer is measured by means of a spring dynamometer, connected by a cord with the external cylinders in such manner that its readings correspond to the difference between the frictional moments of the two cylinders. By this means, the friction in the ball bearings and the influence of the boundary layer of the measured frictional moment are completely eliminated. The frictional moments are measured at a constant running speed of the internal cylinders and a constant temperature maintained by a thermostat.

The viscometer described was used to investigate the relationship between the frictional stress and rate of shear at different temperatures, for a number of lubricating oils, concentrated clay slips (aqueous suspensions), and soap-oil emulsions. Curves are presented of the corresponding values for a consistent, lime grease. Tests of the same grease on a capillary viscometer gave good agreement of the results. The experiments have also shown that, with increasing rate of shear, the effective coefficient of viscosity of the lime grease falls.

The essential advantage of viscosity measurements in suspensions by means of such a rotary viscometer compared with a capillary instrument is that the shear stress is identical at all points in the layer of substance (within practical limits of accuracy).

A. I. Golubev

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

3547. Winternitz, F. A. L., Simple shielded total pressure probes, *Aircr. Engng.* 30, 356, 313-317, Oct. 1958.

3548. Thomas, L. P., III, Flight investigation of the surface pressure distribution and flow field around an elliptical spinner, *NASA Memo.* 1-26-59L, 4 pp. + 5 figs., Feb. 1959.

A dummy, nonrotating spinner was investigated over a Mach number range from 0.65 to 0.95, corresponding to a Reynolds number range from about  $1.6 \times 10^6$  per foot to about  $3.9 \times 10^6$  per foot. The results showed that the local Mach number was less than the free-stream Mach number in the propeller plane but free-stream conditions were approached from about 15 to 90% of the spinner length.

From author's summary

3549. Bidwell, J. M., A rapid method for estimating grit size for fixing transition on wind-tunnel models, *J. Aero/Space Sci.* 26, 2, 118-119 (Readers' Forum), Feb. 1959.

A chart has been prepared, using the results of two well-known papers [Braslow, A. L., *NACA RM L58A17*, Mar. 1958; Chapman, D. R., and Rubesin, M. W., *J. Aero. Sci.* 16, 9, Sept. 1949], that permits a rapid estimation of the grit size required for fixing transition on wind-tunnel models. This chart has been prepared for wings. A similar chart can be prepared for axisymmetric bodies by using the Mangler transformation on the Chapman-Rubesin equations.

Braslow and his associates have shown that if the top of the grit is within the "linear" portion of the boundary layer and if the roughness Reynolds number,  $R_k = (u_k y_k / \nu_k)$ , is equal to or greater than 600, the transition to turbulence will take place at the grit element. Braslow also observed that stabilizing the boundary layer by pressure gradient or cooling does not affect the criterion.

From author's summary

3550. Kehlet, A. B., and Patterson, H. G., Free-flight test of a technique for inflating an NASA 12-foot-diameter sphere at high altitudes, *NASA Memo.* 2-5-59L, 8 pp. + 7 figs., Jan. 1959.

Descriptions of the 12-ft-diameter inflatable sphere, separation mechanism, ejection and disconnect mechanisms, and boosting rocket motors are presented. Also included are the results from preflight vacuum tank tests and flight tests.

From authors' summary

3551. Maki, R. L., Low-speed wind-tunnel investigation of blowing boundary-layer control on leading- and trailing-edge flaps of a large-scale, low-aspect-ratio, 45° swept wing airplane configuration, *NASA Memo.* 1-23-59A, 11 pp. + 2 tables + 10 figs., Jan. 1959.

Lift, drag, and pitching moment were measured at a test Reynolds number of 8.2 million for various combinations of trailing-edge flap deflections ( $0^\circ$  to  $65^\circ$ ) and leading-edge flap deflections ( $0^\circ$  to  $70^\circ$ ) both with and without blowing boundary-layer control. The effects of spanwise distribution of leading-edge flap deflection and boundary-layer control were studied. Blowing flow coefficients ( $C_\mu$ ) up to 0.012 on the trailing-edge flaps and 0.081 on the leading-edge flaps were used. The angle of attack was varied from  $0^\circ$  to beyond that for maximum lift.

From author's summary

3552. McKee, J. W., and Naeseth, R. L., A wind-tunnel investigation of rotor behavior under extreme operating conditions with a description of blade oscillations attributed to pitch-lag coupling, *NASA Memo.* 1-7-59L, 20 pp. + 7 tables + 10 figs., Jan. 1959.

A 1/8-scale model of the front rotor of a tandem helicopter was tested to obtain blade motion and rotor aerodynamic characteristics for conditions that could be encountered in high-speed pullout maneuvers. The data are presented without analysis. A description is given in an appendix of blade oscillations that were experienced during the course of the investigation and of the part that

blade pitch-lag coupling played in contributing to the oscillatory condition.

From authors' summary

3553. Goethert, B. H., Reflection of compression waves in wind tunnels (in German), *Z. Flugwiss.* 5, 11, 313-327, Nov. 1957.

Experimental and theoretical investigations on the testing possibilities of various types of transonic test sections provided the following results for three-dimensional model configurations: The wave system produced by cone-cylinder models cannot be effectively absorbed by either conventional perforated or slotted test-section walls. In the case of perforated test sections, it is relatively easy to eliminate reflections of the initial conical shock and the subsequent compression-wave system by suitable selection of the wall geometry; however, the concentrated expansion-wave system originated at the shoulder of the model would be strongly reflected by such a wall. On the other hand, it is also possible to devise a perforated wall with a geometry such that the conditions of no-reflection for the expansion waves are satisfied; however, in this case the preceding compression-wave system is strongly reflected by the wall. Perforated walls of the conventional or differential-resistance type cannot produce characteristics which support outflow of the test section at lower pressures in the test section. Theoretical considerations show that combined slotted-perforated test-section configurations can be devised which would eliminate this basic difficulty. Tests of a cone-cylinder model with 2% blockage in a suitably selected perforated test section of the differential-resistance type as well as in suitably selected combination perforated-slotted test sections with the slots covered with plates of the differential-resistance type verified the theoretical results and showed that the wave reflection interferences can be eliminated. Further investigation is required to determine which of the two new test-section types will be superior.

From author's summary

3554. Gontier, G., Contribution to the study of the differential interferometer with Wollaston double principle (in French), *Publ. Sci. Tech. Min. Air, France* no. 338, 110 pp., 1957.

This is a report on the interferometer built for the Fluid Mechanics Institute of Lille (France). Reviewer would like to see the issuance of reports on instrumentation as fine and complete as this one becoming a common practice. The description of the polarized light interferometer occupies the central pages of this publication and is preceded and followed by interesting theoretical considerations and methods of operation as well as by calculation procedures for the observations and the errors.

The first part of the publication includes a summary of the various optical methods of visualizing high-speed flow of gases; the use of polarized light for interferometry; the theory of the present instrument; the calibration of the double prism; and the method to carry out the integration to get the density field of the investigated gas.

In several appendixes author discusses: the deviation of a light beam in an isotropic heterogeneous medium and through a transparent plate whose thickness and refractive index are variable; the working and the errors of the interferometer in the general case when the double prism is not at the center of curvature of the mirror; the integration method to get the density of the investigated gas as compared to the computation by finite differences; and, finally, the measurements of the thickness of an homogeneous glass plate that were used to check the instrument.

In the conclusions author states that although the instrument is not so accurate as the classical type, it is easier to operate and it is less expensive.

E. O. Macagno, USA

3555. Lyons, W. C., Jr., The design of an acceleration insensitive skin friction balance for use in free flight vehicles at supersonic speeds, *Henry Beckman Conservation Bull.* 2, Bur. Engng. Res.; Univ. Texas Publ. no. 5811, 18 pp., June 1958.

Paper is a full description of skin-friction balance for use in high-altitude flight tests. The shear force acting on a floating element is transmitted to a linear differential transformer through flexible linkage. The balance is made insensitive to linear and angular acceleration by supporting the floating element by dual systems which are the same in weight and moment of inertia.

According to a simple calculation based on typical data of acceleration of high-altitude rockets, the residual sensitivity to angular acceleration is estimated as below 0.05% of the full scale of balance (50 millipounds). By the acceleration test with a centrifuge, the balance showed good performance for the acceleration up to 13g in any direction. I. Tani, Japan

**3556. Pozniak, O. M., Investigation into the use of Freon 12 as a working medium in a high-speed wind-tunnel, Coll. Aero. Cranfield Note 72, 89 pp. + 3 tables + 93 figs., Nov. 1957.**

## Thermodynamics

(See also Revs. 3499, 3526, 3527, 3537, 3593, 3594, 3625, 3627, 3656)

**Book—3557. Zemansky, M. W., Heat and thermodynamics, 4th ed., New York, McGraw-Hill Book Co., Inc., 1957, xi + 484 pp. \$7.50.**

This book represents the very ambitious undertaking of introducing a student to the subject of thermodynamics, using a rigorous and comprehensive approach from the very start. Describing the concept of temperature, for example, a fairly detailed discussion about temperature measurements, different temperature scales and various thermometers follows; speaking about work, the effects of electricity, magnetism and surface tension are included. The chapter on ideal gases presents a discussion of experimental determination of heat capacities and a derivation of the speed of sound. A chapter on heat transfer contains discussions of laminar and turbulent flow but assumes familiarity with dimensional analysis and gives no derivation of the Stefan-Boltzmann law.

The Giauque temperature scale, the Onsager method of treating irreversible coupled flow, a treatment of dielectric phenomena, of the piezoelectric effect, of second-order phase transitions and the subject of low-temperature physics extend the scope of this book into the realm of modern thermodynamics.

The fourth edition uses essentially the same sequence as the third edition [AMR 5 (1952), Rev. 238] for the material presented. Numerous minor changes are made throughout the book. Chapter 16, describing the physics of very low temperatures, has been extended appreciably and completely rearranged.

Using this book as a text for physics and chemistry students in the junior year, it was found that it is very difficult for the student to separate the important concepts of thermodynamics from the large amount of material presented. Reviewer believes the book represents an excellent text for a graduate course in thermodynamics; few undergraduates can, however, be expected to have a training rigorous and comprehensive enough to appreciate and evaluate the contents of this treatise. The book finds another important application as a reference text for advanced workers in the field of thermodynamics. K. Schneider, USA

**3558. Zabłudowsky, A., Generalized steam power plant heat balance for digital computer application, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Paper. 58-A-213, 7 pp.**

**3559. Solov'ev, E. V., Methods of increasing the power of combined plant units (in Russian), Trudi Mosk. Aviats. In-ta no. 64, 54-80, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 11471.**

An examination is carried out to select parameters for the most suitable constructional design of a combined unit installation,

consisting of a piston engine, a compressor and a turbine, intended for the development of small power consumption. The increase of power in the engine is attained by applying a small degree of compression with a corresponding increase of pressure in the air intake. The above dimensions are selected with the view to get minimum combustion temperatures in the motor cylinder. The proposal is made to use a capacity compressor with internal compression (of the screw type), and a turbine of a radial type, to ensure high performance (k.p.d.) of the turbo compressor unit with a small consumption of air. V. Kh. Abiants

Courtesy *Referativnyi Zhurnal, USSR*  
Translation, courtesy Ministry of Supply, England

**Book—3560. Kittel, C., Elementary statistical physics, New York, John Wiley & Sons, 1958, ix + 228 pp. \$8.**

Book covers important topics in areas of: (1) Fundamental principles of statistical mechanics (24 topics); e.g., Systems and ensembles, Liouville theorem, Microcanonical ensemble, Probability distribution and entropy, Canonical ensemble, Thermodynamic functions, F-D and B-E distributions, Black-body radiation, Negative temperatures. (2) Fluctuations, noise and irreversible thermodynamics (11 topics); e.g., Wiener-Khinchine theorem, Nyquist theorem, Onsager relations, Principle of minimum entropy production. (3) Kinetic methods and transport theory (10 topics); e.g., Detailed balance, H-theorem, Boltzmann transport equation, Magnetoresistance. An Appendix covers such topics as Method of steepest descent, Virial theorem.

Plan of book is to cover highlights of each topic in rarely more than a few pages. Mathematical details are terse but lucid for space allotted. Material is discussed with considerable clarity despite brevity. Reviewer enjoyed the presentations of the Ensemble models for their neat insight. As a condensed source book and entry to more detailed treatments the book is recommended. However, reviewer believes that a large portion of material covered in this book can never be called elementary, and even less justifiably when covered briefly. The conceptual material in this book generally requires great effort for understanding. Though reviewer believes the book to be a fine addition to the field it is not one he would suggest as a first introduction to the subject matter, except to individuals whose scientific sophistication enables them to recognize subtleties despite disarmingly neat presentation. M. Gilbert, USA

**3561. Muckenfuss, C., and Curtiss, C. F., Thermal conductivity of multicomponent gas mixtures, J. Chem. Phys. 29, 6, 1273-1277, Dec. 1958.**

An equation is derived for the complete second approximation to the thermal conductivity of multicomponent gas mixtures. The result is found to be identical with an "approximate" formula for the thermal conductivity derived on the assumption that the thermal diffusion coefficients are negligibly small.

From authors' summary by L. Talbot, USA

**3562. Bird, R. B., Survey of the theoretical formulas for the coefficient of thermal conductivity (in German), Ingenieur 70, 35, 57-62, Aug. 1958.**

Particularly emphasized is the molecular basis for the formulas mentioned and the interconnection between them.

This survey is intended to supplement other summaries on thermal conductivity. It should be emphasized that the subject discussed here is closely related to the problems of predicting viscosity, diffusivity, virial coefficients, and thermodynamic properties. From author's summary

**3563. Powell, R. W., Preliminary measurements of the thermal conductivity and expansion of ice, Proc. Roy. Soc. Lond. (A) 247, 1251, 464-466, Oct. 1958.**

**3564. Hoenig, S. A., Use of a constant current hot wire for the measurement of extreme temperatures, *Rev. Sci. Instrum.* 29, 8, 704-705, Aug. 1958.**

A nonsteady-state method is used for measuring gas temperature in a flow. Temperature-time exponential behavior of a hot wire is experimentally obtained. Curve-fitting, in principle, gives both the true gas temperature and the wire time constant, assuming the latter to be constant in the observed temperature region. Wire temperature is limited to about 600°C to avoid error due to radiation. Author claims method is useful for obtaining true gas temperatures far in excess of wire melting point, since one of the curve-fitting parameters is the gas temperature.

Reviewer feels that for gas temperatures far in excess of the observed interval (above 2000°C) the curve fit becomes increasingly inaccurate due to experimental spread. A possible improvement may be obtained by not merely repeating measurements but by repeating with wires of different diameters (e.g. see AMR 7 (1954), Rev. 2677). M. Gilbert, USA

**3565. Shaffer, L. H., Wavelength-dependent (selective) processes for the utilization of solar energy, *Solar Energy* 2, 3/4, 21-26, July/Oct. 1958.**

The theoretical maximum work obtainable from solar-powered selective absorber thermal devices is calculated. The calculations are based upon ideal systems operating with the Carnot efficiency. This paper presents information of value to the worker in solar power, and represents an extension of the work reported by H. Tabor, "Transactions of the Conference on the Use of Solar Energy," V. II, Part 1, Section A, p. 24, and J. T. Gier and R. V. Dunkle, op. cit. p. 41. R. V. Dunkle, USA

**3566. Tabor, H., Stationary mirror systems for solar collectors, *Solar Energy* 2, 3/4, 27-33, July/Oct. 1958.**

The use of mirrors to increase the performance of solar collector is discussed, and methods of using semi-fixed mirrors, when tilt is varied with the season but not daily, are presented by which the collector temperature or effectiveness can be increased. Cylindrical parabolic mirrors are used to concentrate the solar energy and are adjusted for the season. Further gains can be made by use of small auxiliary mirrors. Reviewer believes this to be a valuable contribution to the solar energy field.

R. V. Dunkle, USA

**3567. Braum, W. A., and Strong, J. D., Basic optical consideration in the choice of a design for a solar furnace, *Solar Energy* 2, 3/4, 37-45, July/Oct. 1958.**

Paper discusses single- and double-mirror systems for concentrating solar radiation for high-flux solar furnaces. It is pointed out that a two-mirror system has certain theoretical advantages over the paraboloidal mirror, and such a system is described in some detail. This is a valuable contribution and should lead to further thought in the design of optical concentrating systems for solar energy.

R. V. Dunkle, USA

**3568. Hughes, G., A solar furnace using a horizontal heliostat array, *Solar Energy* 2, 3/4, 49-51, July/Oct. 1958.**

Paper presents another possible condenser-heliostat combination for high-flux furnaces. A two-component solar furnace, condenser-heliostat combination, is described in which the condenser faces downward at 30° toward a heliostat comprised of numerous rows of plane mirrors mounted on a horizontal turntable. It is shown that for a south-facing condenser, with the angle of the final flux beam limited to 30° below the horizontal, the rows of heliostat mirrors may be mounted so they overlap, resulting in a reduction of the edge losses occurring when the heliostat mirrors are all held in a single plane. The overall size of the heliostat turntable is calculated for a 6-hour workday throughout the year, and a suggestion is made for using the heliostat control mecha-

nism to provide shutter action. The saving in flux possible by the elimination of an independent shutter is estimated at about eight per cent.

This paper should be of value to anyone planning construction of a large solar furnace. R. V. Dunkle, USA

**3569. Gabbay, E. J., Some aspects of refrigeration in supersonic aircraft, *J. Roy. Aero. Soc.* 62, 575, 769-786, Nov. 1958.**

Author reviews some of the basic aircraft refrigeration schemes, with particular reference to their performance in high-speed flight and the power penalties implied in this form of cooling; mainly for the Mach number range from 1.5 to 2.5. Systems in current use and for potential use are examined. Essential thermodynamic and performance aspects are highlighted. For clarification, fundamental concepts are outlined. P. W. Whitton, England

## Heat and Mass Transfer

(See also Revs. 3216, 3217, 3237, 3250, 3465, 3480, 3489, 3495, 3499, 3501, 3504, 3557, 3560, 3561, 3562, 3563, 3564, 3565, 3566, 3567, 3568, 3569, 3624, 3632, 3659, 3669, 3687, 3688)

**Book—3570. Brown, A. I., and Marco, S. M., Introduction to heat transfer, New York, McGraw-Hill Book Co., Inc., 1958, 3rd edition, xvi + 332 pp. \$6.75.**

The object of this book, as with previous editions, has been to present the fundamentals of heat transfer in a manner readily understandable to engineering students and engineers in practice who have had the usual curricula provided in the first two years of engineering. The major changes in this edition have been the addition of two new chapters and notable additions to two others. One of the new chapters concerns fluid flow in the convection process, and is intended to serve as a review of the principles of fluid flow that are pertinent. The second new chapter deals with graphical and numerical methods applied to heat conduction. The chapter which formerly dealt with dimensional analysis has been amplified by additional material on fundamental units and their relationships. In the chapter on application of the principles to design problems, a section has been added dealing with the design of electrical transformers.

The book comprises fourteen chapters and an appendix. Chapter one is a general discussion of the various modes of heat transfer. Chapter two, entitled "Heat transfer by conduction," is mainly concerned with a discussion of thermoconductivity and means by which it is measured, including some discussion on the accuracy of methods. Chapter three presents a discussion of the calculation of steady-state conduction. Radiation is discussed in Chapter four. Chapter five discusses fundamental units and dimensional analysis. Chapter six reviews fluid flow principles in the convection process, followed by Chapter seven in which the forced-convection heat-transfer process is discussed in detail. Free or natural convection is covered in Chapter eight. Heat transfer in boiling and condensation is subject of Chapters nine and ten. The overall transfer of heat combining the various modes is treated in Chapter eleven. The application of heat-transfer principles to design problems is covered in Chapter twelve. Transient conduction is discussed in Chapter thirteen, while graphical and numerical methods for conduction, both transient and steady-state, are covered in Chapter fourteen. The appendix contains several mathematical derivations, including the derivation of the Stefan-Boltzman law from Planck's equation and derivation of equation of net radiation exchange between two black-bodied surface elements. In addition, the appendix contains charts showing variation of properties of materials with temperature.

In the first chapter, the three modes of heat transfer are briefly discussed in a qualitative sense and should give the student an

excellent "feel" for the general heat-transfer problem. Authors have made one slight error of omission in the first chapter in the very first paragraph in their discussion of the Laws of thermodynamics. In the discussion it is stated that the heat may be transferred from a high-temperature region to one of lower temperature, but never from a low-temperature region to one of higher temperature. Authors should have added at the end "without the application of work." This omission is likely to be confusing to students who have a weak background in thermodynamics because one would immediately wonder how a household refrigerator functions. The second chapter starts out with a phenomenological derivation of the Fourier law. However, the chapter is mainly devoted to the concept of thermoconductivity of solids, gases and liquids, including a listing of representative values for various materials and a brief discussion of the means for measuring conductivity. In the discussion of thermoconductivity of fluids, the student is briefly introduced to equations used to calculate thermoconductivity such as Maxwell's equation relating thermoconductivity to specific heat and absolute viscosity. The chapter concludes with a table listing orders of magnitude of thermoconductivity for the various classes of material. Such a table is invaluable to the student. The reviewer believes that authors should have included more material on thermoconductivity measurements, particularly at the higher temperatures. While the measurement of thermoconductivity at very high temperatures is admittedly very unsettled at the moment, the student should nevertheless have been made acquainted with the problems involved.

Chapter three on steady-state conduction develops the usual equations for steady-state conduction for the various standard-type problems encountered. The one good feature in the authors' presentation is the simultaneous analogous electrical circuit concept. Reviewer has always been in favor of such a procedure because he has encountered too many students who could solve a particular flow problem if the flowing medium were heat, but could not solve the same problem if the flowing medium were electric current, and vice versa. The chapter is completed by a large number of good problems which should definitely be of value to the student. Chapter four on radiation begins with a very brief discussion of the energy spectrum distribution of black-body radiation. Reviewer believes that it would be most helpful to the students if this section were expanded a little to include a review of the electromagnetic spectrum to show the reader where thermoradiation fits into the overall radiation picture. The spectral distribution is followed by an historical and phenomenological discussion of radiation, introducing the concepts of absorption, reflection and transmission. The concept of monochromatic emissive power, the black-body concept, the introduction of the well-known Planck's equation, the relationship between absorptivity and emissive power and an extensive table covering values of emissivity for many materials are also included. The quantitative aspects of radiation are treated using the original Hottel area and emissivity factors. Reviewer feels that this area-emissivity-factor concept is obsolete and he would rather have seen the introduction of Hottel's later treatment involving the one overall factor concept. There are other treatments of the problem besides Hottel's, such as those discussed by Oppenheim and others, but reviewer is most familiar with the Hottel system. Reviewer also believes that some attention, at least, should have been paid to the subject of infrared sensors and detection, since this field has become so prominent of late.

Chapter five on fundamental units and dimensional analysis is very well done. Authors introduce the dimensional system involving both pounds force and pounds mass utilizing the  $G_C$  concept. Reviewer decided thirteen years ago that the only unit system making sense is the one utilizing the  $G_C$  concept and used it exclusively in his courses with a high degree of success. He is happy to see it appear in this particular book. Perhaps the most difficult problem an engineering student has to face is acquiring a clear concept of units and dimensions. The authors have done a very

nice job of clarifying the situation. The section on dimensional analysis utilizes the Buckingham Pi theorem and again is very well treated. Reviewer has never used the Pi theorem but a somewhat different system of dimensional analysis purely because he found it easier, but the authors have certainly done a very good job introducing dimensional analysis.

Chapter six presents a brief discussion of fluid flow in convection with a very minimum discussion of the boundary layer. The general treatment in this chapter is one that can be found in most undergraduate texts on fluid flow where compressible flow is not emphasized. Reviewer would like to have seen more space devoted to boundary-layer theory, particularly as it effects heat transfer, in the very-high-speed range as well as the low-speed range.

Various forced-convection heat-transfer equations are developed in Chapter seven. Equations are derived by dimensional analysis and some space is devoted to a discussion of the strictly empirical approach and the mathematical approach. Emphasis is placed on proper use of units and evaluation of the physical and thermal properties at the appropriate reference temperatures. Several interesting cases, however, are not included in the chapter, as, for instance, heat transfer in the high-speed case where recovery factors and adiabatic wall temperatures must be used. Also some of the modern work on heat transfer in starting lengths is not included, but this is probably caused by the fact that much of the information was not available at the time the manuscript was submitted to the publishers.

Free convection is treated in Chapter eight as a special case of forced convection, as was done in the previous edition. The velocity term in the Reynolds number is replaced by the appropriate term including the driving force temperature difference and the value of gravity resulting in the development of the Grashof number. This approach has not been used by too many other authors, and reviewer feels it is a good one from the student's standpoint because it should assist the student in getting a firmer grasp of convection heat transfer.

Heat transfer to boiling liquids and condensing vapors are treated separately in Chapters nine and ten. The chapter on boiling contains almost no references to much of the modern work on boiling that has been done in the past ten years. For example, authors could have included some of the theoretical work of Zuber and Griffith and the experimental work of Rohsenow, Griffith, Westwater and others. It is admitted that some of this work may not have been available at the time the authors submitted their manuscript; however, there has been sufficient work done in the past ten years to warrant at least a passing mention in the text. Likewise the chapter on condensation is devoid of any references to work published later than 1935.

The overall transfer of heat is summed up in Chapter eleven, which includes several tables of representative values of heat-transfer coefficients for various forms of building construction and various types of heat transfer units. Such data are invaluable to the student. In this chapter is mentioned the Nickells heat meter used for determining overall coefficient; however, the ASHRAE has developed a far superior heat-flow meter, but this is not mentioned. Nowhere in the chapter is mention made of the tremendous amount of work that has been done on efficient, compact heat exchangers, such as the extensive work of London.

The application of the principles studied in the first eleven chapters are emphasized in Chapter twelve which discusses some of the practical problems one may be confronted with; for example, calculating feed water heaters, surface condensers, fin-tube fan coils, dehumidifying coils, and a fairly long section on calculation of heat transfer in electrical transformers. An example for each particular type of problem is worked out in detail to illustrate the manner and extent to which transfer principles may be applied, and to show how these principles must be modified or extended in order to produce a rational design. The student should find this chapter most interesting and instructive.

Several of the standard-type transient conduction problems are discussed in Chapter thirteen. Equations are derived using the principles of dimensional analysis. The general transient conduction equation is presented in toto without being derived. The chapter is concluded by the addition of several Groeber charts.

The concluding chapter in the book discusses the various graphical and numerical means for determining temperature field for both steady and transient conduction. Included are the method of curvilinear squares, the Schmidt graphical method, and the Emmons network system.

In general, the book has many desirable features; the most important being, in the reviewer's opinion, the strong emphasis on the practical aspects of heat transfer, designed to give the student a full appreciation for the nonideal situations that designers of heat-transfer equipment are confronted with. Several undesirable features are found in the book, including a lack of completeness by an apparent disregard for much of the modern work in heat transfer. Reviewer has no recommendations to make regarding the adoption of this text because each reader will have to weigh the various disadvantages of the book with its many advantages. Reviewer also acknowledges that some of his criticisms can probably be classed as personal preferences.

R. J. Mindak, USA

**3571. Strickland, P. R., The thermal equivalent circuit of a transistor, IBM J. Res. Devel. 3, 1, 35-45, Jan. 1959.**

An exact electrical analog is given for the thermal system between the collector junction and the constant-temperature environment of a transistor. For this circuit analog, the voltage response to an applied current is equivalent to the temperature response of the collector junction to an applied-power dissipation. The objective of this paper is (1) to prove that this thermal equivalent circuit is entirely consistent with the rigorous, academic approach to the problem, which is to solve a boundary-value problem for heat flow in the transistor system; (2) to present an experimental method for obtaining the circuit parameters in the thermal equivalent circuit; and (3) to demonstrate the utility of the thermal equivalent circuit for the circuit designer and the transistor designer.

From author's summary

**3572. Brull, M. A., and Vinson, J. R., Approximate three-dimensional solutions for transient temperature distribution in shells of revolution, J. Aero/Space Sci. 25, 12, 742-750, Dec. 1958.**

An approximate formulation of Fourier's heat-conduction equation is developed for thin shells of revolution by making assumptions similar to those of the theory of thin elastic shells. It is shown that the resulting partial differential equation is separable for all shell shapes and that solutions may be obtained in terms of known functions. It is also shown, for a broad class of problems, that solutions can be expressed as combinations of a one-dimensional slab solution and suitably defined correction functions. These techniques should be of particular value as an alternate for numerical techniques which require use of large, high-speed computers for estimating temperatures of aircraft and missile structures.

W. B. Hendry, USA

**3573. Chow, T.-S., On the solution of certain differential equations by characteristic function expansions, Quart. Appl. Math. 16, 3, 227-235, Oct. 1958.**

Author considers the differential equation

$$p_0 \frac{\partial^2 u}{\partial x^2} + p_1 \frac{\partial u}{\partial x} + p_2 u = \frac{\partial u}{\partial t} = \sigma$$

for  $a \leq x \leq b$ ,  $0 \leq t$ , where  $p_0$ ,  $p_1$ ,  $p_2$  are functions of  $x$ . The initial condition is  $u(x, 0) = u_0(x)$ , and the boundary conditions are

$$\alpha_1 u(a, t) + \alpha_2 u(b, t) + \alpha_3 \frac{\partial u}{\partial x}(a, t) + \alpha_4 \frac{\partial u}{\partial x}(b, t) = f(t),$$

$$\beta_1 u(a, t) + \beta_2 u(b, t) + \beta_3 \frac{\partial u}{\partial x}(a, t) + \beta_4 \frac{\partial u}{\partial x}(b, t) = g(t)$$

where  $\alpha_i$ ,  $\beta_i$  are constants. After transforming the problem into one with a nonhomogeneous differential equation and homogeneous boundary conditions the method of separation of variables can be applied. However, the problem is in general not self-adjoint and therefore the bi-orthogonal eigenfunctions  $\psi_n(x)$ ,  $\chi_n(x)$  of two adjoint systems are needed. Assuming that the right hand side of the differential equation can be expanded into a series of functions  $\psi_n(x)$ , and that the solution of the transformed problem has form  $\sum_{n=1}^{\infty} F_n(t) \psi_n(x)$ , author gives the formal solution  $u(x, t)$  of the original system.

As an example author applies his procedure to the diffusion equation in the axially symmetric case

$$\frac{\partial^2 u}{\partial r^2} + \frac{1}{r} \frac{\partial u}{\partial r} - \frac{\partial u}{\partial t} = \sigma.$$

R. Albrecht, Germany

**3574. Reid, W. P., Heat flow in a cylinder, Quart. Appl. Math. 16, 2, 147-153, July 1958.**

An equation is derived for the time-dependent radial temperature distribution in a long cylinder which is exchanging heat with its environment through a thin-walled tube surrounding it. The rates of heat transfer between cylinder and tube and between tube and environment are taken to be proportional to the respective temperature differences. The mathematics of the derivation is probably a little beyond most engineers. Graphical representation of the results obtained would greatly have enhanced the value of this work to engineers.

R. Gardon, USA

**3575. Delavault, H., Application of Laplace transforms and Hankel transforms to the solution of the heat equation and to the solution of Maxwell's equations in cylindrical coordinates (in French), Publ. Sci. Tech. Min. Air, France NT 71, 99 pp., 1957.**

Conditions to be satisfied by a function  $f(s)$  if it is to determine a unique inverse Laplace-transform  $F(t)$  are given, and the uniqueness proved, in the cases (1) where  $f(s)$  is given as a uniformly convergent series of L-transforms and (2) when  $f(s)$  is given at an infinity of points having a point of accumulation at infinity. These results lead to the proofs of some asymptotic properties of L-transforms in two variables. Infinite and finite Hankel transforms are considered and conditions established for term-by-term differentiation of the Dini series expansion. Conditions for the convergence of transformations with respect to two variables, an L-transform with respect to one, and an H-transform with respect to the other, are derived and further properties discussed.

These results are applied to the solution of heat-conduction problems using cylindrical co-ordinates  $(r, \theta, z)$  for a solid bounded by parallel planes  $z = 0$ ,  $z = 1$ . A second application is to a solution of Maxwell's equations inside a semi-infinite cylinder given the initial electromagnetic field and, in the first case, tangential components of  $E$  on the cylinder surface, and, in the second case, tangential components of both  $E$  and  $H$  at the end only. Solutions are obtained for both homogeneous and nonhomogeneous forms of Maxwell's equations. An L-transformation with respect to time is used together with a finite H-transformation in the space variables, and the methods used rigorously justified.

Reviewer regards this work as an important contribution to the theory of integral transforms, which succeeds in placing the formal technique required for certain problems on a satisfactory analytical foundation.

R. P. Pearce, Scotland

3576. Dul'nev, G. N., and Kondrat'ev, G. M., Generalization of the theory of regular thermal conditions (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 71-85, July 1956.

Paper is a development of Kondrat'ev's theory of regular thermal conditions, to include sources and sinks whose strengths do not vary with time. The body considered is surrounded by a fluid whose temperature also does not vary with time, and the thermal properties and heat-transfer coefficient are taken as independent of temperature. Certain properties about the rates of cooling or heating were tested experimentally. Y. R. Mayhew, England

3577. Zingerman, A. A., Effect of heat conduction on electric erosion in metals (in Russian), *Zh. Tekh. Fiz.* 26, 9, 2008-2020, Sept. 1956.

3578. Goulard, R., On catalytic recombination rates in hypersonic stagnation heat transfer, *Jet Propulsion* 28, 11, 737-745, Nov. 1958.

Laminar, hypersonic flow heat transfer near a forward stagnation point is treated considering dissociation and recombination behind the shock wave. Analysis is presented for the case of constant Prandtl and Schmidt numbers and for the specification  $\mu\rho = 1$ . Finite catalytic recombination rates are introduced by means of a correction parameter which is a function of the flight condition, nose geometry and the wall catalytic recombination rate. Analytically determined results are shown of the heat flux as a function of speed and catalytic reaction rate. Results indicate that heat transfer by catalytic action increases with velocity, nose diameter and wall temperatures and decreases with altitude. The analytical results in conjunction with other experimental observations on the catalytic recombination rates of oxygen and nitrogen for various surfaces indicates a superiority of pyrex surfaces over metallic surfaces for nose materials. R. M. Drake, Jr., USA

3579. Toor, H. L., Heat transfer in forced convection with internal heat generation, *AIChE J.* 4, 3, 319-323, Sept. 1958.

A solution to this problem is obtained for viscous flow in a tube in the case of Newtonian and power-law non-Newtonian fluids with constant physical properties and with the heat generation on arbitrary function of radius. Examples include the heat transfer with frictional heat generation in a non-Newtonian fluid, the problem in which a fluid enters a tube in laminar flow with an arbitrary temperature profile, and a first approximation to the case of heat transfer in a turbulent fluid in which heat is being generated.

From author's summary by D. W. Dunn, Canada

3580. Buckland, Mrs. B. O., When air is the coolant, *Prod. Engng.* 30, 7, 54-57, Feb. 1959.

Author gives a quick way to estimate whether the assembly will run too hot—and whether the self-cooling methods of radiation or convection can handle the trouble. She supplies the necessary equations and heat-transfer coefficients to do the complete job.

From author's summary

3581. Van Dijk, Sj., Hall, J. A., and Leaver, Vera M., The influence of rate of cooling on the zeros of mercury-in-glass thermometers, *J. Sci. Instrum.* 35, 9, 334-338, Sept. 1958.

A study of the effect of rate of cooling on the temporary depression of the zero of high-range mercury thermometers has been made from two points of view. It is concluded that if the cooling rate is sufficiently slow (about 15 hr to cool from 400 C to room temperature) the temporary depression is completely suppressed. It is also concluded that, from the point of view of a "permanence of range" or "bulb stability" test, the best discrimination between different batches of thermometers is obtained when the zeros are determined after slow cooling. From authors' summary

3582. Seiff, A., and Short, Barbara J., An investigation of supersonic turbulent boundary layers on slender bodies of revolution in free flight by use of a Mach-Zehnder interferometer and shadowgraphs, *NACA TN* 4364, 27 pp. + 18 figs., Sept. 1958.

Instantaneous density distributions across the boundary layer were obtained at Mach numbers of 3.2 and 3.6 and at length Reynolds numbers up to 25 million for body surfaces cold compared with the recovery temperature. Density distributions obtained by averaging the instantaneous distributions agreed well with the distributions calculated by Crocco's equation and the assumption of a power law for the velocity profiles. Average heat-transfer rates calculated by the modified Reynolds analogy were in satisfactory agreement with the heat-transfer rates calculated by an energy balance equation that makes use of the measured density profiles and boundary-layer thickness and that is analogous to the momentum equation.

Interferometer measurements showed the density distributions to contain irregularities with a scale comparable with the boundary-layer thickness and with an appreciable magnitude compared with the total range of variation in the mean density profiles. Authors state that the shadowgraph pictures show a repeating pattern of spot images with a definite regularity; they believe these spots to be shadowgraphs of individual eddies in the turbulent boundary layer. N. Tetervin, USA

3583. Hasegawa, Y., Heating load characteristics of a passenger car, *Bull. JSME* 1, 3, 262-268, Aug. 1958.

Author defines and describes the thermal system for a typical 88-passenger railroad car (coach) of Japanese National Railway. He shows how to make tests and compute heating loads for car at rest or running, in either thermal steady-state or transient condition. Data on test car are presented for roof ventilating system, heating coils, structural and interior thermal capacitances, thermal resistances, and thermal output of passengers. Paper gives block circuit diagram for car heating system and presents its dynamic response. Author indicates how system parameters are obtained from dynamic response tests on actual car and gives typical data. He concludes that predictions from model, dynamic or steady-state, agree well with measured performance.

H. B. Nottage, USA

3584. Sparrow, E. M., and Gregg, J. L., Prandtl number effects on unsteady forced-convection heat transfer, *NACA TN* 4311, 10 pp. + 1 table + 3 figs., June 1958.

An analysis is presented of the unsteady laminar boundary-layer flow over a flat plate with a prescribed time-dependent plate temperature. Following the analysis of a previous paper [AMR 11 (1958), Rev. 623] a series solution is developed in terms of expansion parameters which are a measure of time required for temperature changes to diffuse across the boundary-layer thickness and which are directly related to time derivatives of the prescribed plate temperature. The resulting differential equations are machine-integrated for Prandtl number values of 0.1, 0.72, 1.0, and 10. These results for the instantaneous heat-transfer rate are compared with corresponding results obtained by quasi-steady temperature analyses. As would be expected, the comparison is good for low Prandtl numbers and becomes significantly worse with increasing Prandtl numbers. P. Chiarulli, USA

3585. Chow, T.-S., On a problem of heat conduction with time-dependent boundary conditions (in English), *ZAMP* 8, 6, 478-484, Nov. 1957.

Solved is the following problem: To find temperature distribution in a homogeneous cylinder of finite length,  $0 \leq \rho \leq r$ ,  $|z| \leq s$ , with given initial temperature

$$u(\rho, \varphi, z, 0) = u_0(\rho, \varphi, z) \quad (t = 0)$$

and with boundary conditions

$$\frac{\partial u}{\partial \rho} + b_1 u = f_1(\varphi, z) \alpha_1(t) \quad (\rho = r),$$

$$\frac{\partial u}{\partial z} + b_2 u = f_2(\rho, \varphi) \alpha_2(t) \quad (z = s),$$

$$\frac{\partial u}{\partial z} - b_3 u = f_3(\rho, \varphi) \alpha_3(t) \quad (z = -s)$$

( $b_1, b_2, b_3$  positive constants), prescribed on the surface of the cylinder.

Author supposes the solution in the form

$$u(\rho, \varphi, z, t) = \psi(\rho, \varphi, z, t) + \sum_{l=1}^3 X_l(\rho, \varphi, z) \alpha_l(t) \quad [1]$$

where the functions  $X_l (l = 1, 2, 3)$  are solutions of the equations

$$\frac{\partial^2 X_l}{\partial \rho^2} + \frac{1}{\rho} \frac{\partial X_l}{\partial \rho} + \frac{1}{\rho^2} \frac{\partial^2 X_l}{\partial \varphi^2} + \frac{\partial^2 X_l}{\partial z^2} = 0 \quad [2]$$

with boundary conditions

$$\frac{\partial X_l}{\partial \rho} + b_1 X_l = \delta_{l1} f_1(\varphi, z) \quad (\rho = r),$$

$$\frac{\partial X_l}{\partial z} + b_2 X_l = \delta_{l2} f_2(\rho, \varphi) \quad (z = s),$$

$$\frac{\partial X_l}{\partial z} - b_3 X_l = \delta_{l3} f_3(\rho, \varphi) \quad (z = -s) \quad [3]$$

( $\delta_{lm} = 1$  for  $l = m$ ,  $\delta_{lm} = 0$  for  $l \neq m$ ).

For the function  $\psi$  author gets then a differential (nonhomogeneous) equation with homogeneous boundary conditions

Author first solves the problem [2], [3], assuming  $X_l(\rho, \varphi, z)$  in the form  $R(\rho)\phi(\varphi)Z(z)$ . Having got  $X_l$  in the form of infinite series, he solves the problem for  $\psi$ . The solution  $u$  is then given by [1].

Paper was suggested by a recent paper of V. Vodička [ZAMP 8, 1, p. 53, 1957], where a similar problem is solved, but with boundary conditions which are periodic functions of time; for some partial results, readers are referred to Vodička's paper.

K. Rektorys, Czechoslovakia

**3586. Mark, R. M., Effect of externally generated vorticity on laminar heat transfer** *J. Aero. Sci.*, **24**, 12, 923-924 (Readers' Forum), Dec. 1957.

**3587. Liapin, M. F., Heat transfer and aerodynamic resistance to bundles of smooth tubes in a gas stream at high Reynolds numbers** (in Russian), *Teploenergetika* **3**, 9, 49-52, Sept. 1956.

**3588. Ostrach, S., and Braun, W. H., Natural convection inside a flat rotating container**, *NACA TN 4323*, 19 pp. + 6 figs., Sept. 1958.

Froude number is found to be the parameter that determines the effect of body rotations on internal natural convection flows. Explicit forms of Froude number are determined for the cases of predominant rotation and predominant axial force. In a heated cylindrical container no significant convective effects are generated by rotations alone. Moreover, rotation tends to inhibit the flow and heat transfer generated by an axial body force in such a configuration. Insertion of radial vanes in the container eliminates the detrimental effects of rotation and improves the heat transfer. It is suggested that this type of arrangement may serve as a suitable

heat sink in the nose cone of a high-speed vehicle entering the atmosphere.

From authors' summary by J. A. Businger, USA

**3589. Poots, G., Heat transfer by laminar free convection in enclosed plane gas layers**, *Quart. J. Mech. Appl. Math.* **11**, 3, 257-273, Aug. 1958.

The streamlines and isotherms in a viscous fluid in two-dimensional motion in a rectangular cylinder with horizontal axis are computed by expressing temperature as a double Fourier series and the stream function as a double series of orthogonal polynomials. The solution is determined by the Rayleigh number ( $A$ ), the Prandtl ( $\sigma$ ) number, the Nusselt number (giving the heat flux), the aspect ratio of the rectangle, and the inclination of the faces to the vertical. The temperature is assumed constant on two opposite faces and either it is taken as linear on the other faces or the heat flux there is taken as zero.

The solution is calculated for a square section with the vertical sides at different temperatures, and the arithmetic is checked by relaxation of the values obtained from the double series. The results are displayed in a graph of Nusselt ( $N$ ) number against Grashof number ( $A/\sigma$ ), showing that for small temperature differences the heat flux is proportional to temperature gradient, but for large gradients the motion becomes dominant and  $N \propto (A/\sigma)^{1/4} + \text{const.}$

In the center of the cell is an isothermal region of constant vorticity, as had been postulated by Batchelor.

Details of the derivation of the coefficients in the double series and of the numerical technique are summarized in appendices. More discussion of the physical significance of the results would have been welcome, for they are extremely interesting.

R. S. Scorer, England

**3590. Hara, T., Heat transfer by laminar free convection about a vertical flat plate with large temperature difference**, *Bull. JSME* **1**, 3, 251-254, Aug. 1958.

Author considers the problem of laminar, free-convective, boundary-layer flow along a semi-infinite vertical plate for the case when the coefficient of viscosity  $\mu$  is proportional to  $T^m$ , where  $T$  is the absolute temperature. The Prandtl number is assumed to be constant; its numerical value is not given explicitly but appears to be about 0.72. After deriving a system of ordinary differential equations for the similarity flow, author calculates the velocity and temperature distributions for the cases  $m = 0.76$  and  $m = 1$ . (The latter case, of course, is easily derived from the case  $m = 0$  by the Howarth transformation.)

The results are presented for two values,  $\epsilon = 2$  and 4, of the parameter  $\epsilon = (T_0 - T_1)/T_1$ , where  $T_0$  and  $T_1$  are the absolute temperatures of the wall and ambient fluid respectively. The main result is that the heat transfer at the wall for the case  $m = 0.76$  is proportional to  $(1 + 0.055\epsilon)$  times the heat transfer for  $\epsilon = 0$ . The case  $\epsilon = 0$  is the case of very small temperature difference, compared with the absolute temperature, and is thus seen to be equivalent to  $m = 0$  [see Ostrach, *NACA Rep.* 1111, 1953 for details of this case; AMR **7** (1954), Rev. 306; **5** (1952), Rev. 3233].

J. T. Stuart, England

**3591. Ostroumov, G. A., Nonstationary heat convection near a horizontal cylinder** (in Russian), *Zh. Tekh. Fiz.* **26**, 12, 2720-2730, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11678.

An experimental investigation was made of the thermal convection near a fine ( $d = 0.1$  mm) platinum wire, placed horizontally in the initial stage after connection with a direct current supply. The tests were carried out in water, alcohol and transformer oil and in air. Details of the tests are: visual observation of the convection flow by the method of light-dispersing particles; observation of the temperature gradients in the flow by the method of the optical grid and of the changes of temperatures of the heat-emitting wire by

means of a bridge not in equilibrium. Some quantitative results are given: the velocity of lift of the hot cone of liquid and the duration of the delay in break-away of the hot mass of liquid from the wire in relation to the degree of heating, the character of the increase of temperature of the wire from the moment of connection with the current, and so forth.

G. A. Tirsikii

*Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England*

**3592. Tanaev, A. A., Effect of free convection on friction factor of a flat plate with laminar flow in boundary layer** (in Russian), *Zh. Tekh. Fiz.* **26**, 11, 2563-2569, Nov. 1956,

Author presents approximate mathematical solution for the effect of free convection on the friction factor  $c_f$  of a gas flowing past a flat plate, the plate having any inclination  $\alpha$  to the field of gravity. The solution assumes small values of  $Gr/Re^2$ , and the result is presented in form  $c_f/c'_f = \phi(Gr \cos \alpha/Re^2)$ , where  $c'_f$  is the friction factor in the absence of free convection.

Y. R. Mayhew, England

**3593. Wade, W. R., Measurements of total hemispherical emissivity of several stably oxidized metals and some refractory oxide coatings**, NASA Memo. 1-20-59L, 10 pp. + 1 table + 19 figs., Jan. 1959.

Methods used to obtain oxide coatings of high emissivity suitable for application to the radiative cooling of hypersonic aircraft are presented. Values of total hemispherical emissivity were obtained for several high-temperature materials including type 347 stainless steel and Haynes alloys, C, X, and 25. Tests were also conducted on tungsten and Haynes alloy B but, because of the nature of the oxide coatings produced, values of emissivity were not obtained. Measurements of the total normal emissivity of flame-sprayed coatings of alumina and zirconia are also included.

From author's summary

**3594. Jenness, J. R., Jr., The effect of surface coatings on the solar radiation equilibrium skin temperature of an earth satellite**, *Solar Energy* **2**, 3/4, 17-20, July/Oct. 1958.

Paper discusses the importance of the spectral characteristics of satellite surfaces on the equilibrium temperature of the satellite. This paper is of little value to one conversant with the problem, but may be of interest to those unfamiliar with the problems involved in temperature control of space vehicles. General equations are written for the energy balance assuming radiation from the earth to be negligible, and numerical calculations are made for two types of surfaces.

R. V. Dunkle, USA

**3595. Ishigai, S., Yamasaki, Y., and Hashimoto, A., Calculation of gas radiation from a rectangular parallelepiped gas mass surrounded by transparent gas (1st report, The emissivity of a gas mass radiating to furnace walls)**, *Bull. JSME* **1**, 3, 255-261, Aug. 1958.

The average emissivity of a gas mass radiating to furnace walls and the average absorptivity of the gas mass for radiation between any two walls of a furnace are calculated.

E. Sunderland, USA

**3596. Hartnett, J. P., Eckert, E. R. G., and Birkebæk, R., The emissivity and absorptivity of parachute fabrics**, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-125, 6 pp.

**3597. Tananayko, Yu. M., The heat loss in the boiling of a downward-flowing water film** (in Russian), *Izv. Kievsk. Politekh. In-ta* **17**, 75-82, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9110.

The work is concerned with experiments to determine the heat loss from a film of water (of a thickness of 0.25 mm), flowing down inside a glass tube at atmospheric pressure. The tube was heated

externally. The unit weight flow of the water descending in the film varied from 20 to 400 kg/hr.

It was found that in the experimental conditions, two conditions of heat loss are present in the boiling of water in a downflowing film, depending on  $G$ . The coefficient of heat transfer from the wall to the film can be expressed by the empirical formula

$$\alpha = 22 q^{0.827} \text{ for } G \geq 150 \text{ kg/m/hr}$$

$$\alpha = 8.15 q^{0.6} \text{ for } G < 150 \text{ kg/m/hr}$$

in which  $q$  is the specific heat loading.

It is observed that, for water boiling in a film, the value of  $\alpha$  is some 10% lower than for the boiling of water in a pipe.

V. P. Mugaley

*Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England*

**3598. Ushkalov, V. P., Boundary deformations of the foundations of installations on thawing soils** (in Russian), *Trudi N.-i. In-ta Osnovani i Fundamentov* no. 29, 80-88, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12031.

Factual data are produced for foundation settlements of six groups of buildings and installations. Values are given for the safety limits of curvature, sagging and deflection, with consideration for the rate of settlement. These values are somewhat higher in comparison with those for buildings and installations built on non-freezing soils.

K. E. Egorov

*Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England*

**3599. Williams, F. A., Elementary derivation of the multicomponent diffusion equation**, *Amer. J. Phys.* **26**, 7, 467-469, Oct. 1958.

It is demonstrated that the multicomponent diffusion equation can be derived from elementary, kinetic-theory considerations without employing the results of the mathematical theory of nonuniform gases. By using the approach described by Furry, elementary expressions for the binary diffusion coefficients are also obtained. The advantage of the concept of the equivalence of partial pressure gradients and momentum gradients is thereby emphasized.

From author's summary by E. V. Somers, USA

**3600. Bauer, E., and Zlotnick, M., Evaporation into a boundary layer**, *Phys. Fluids* **1**, 4, 355-356, July-Aug. 1958.

This brief note presents an analysis of the equations relating surface resistance and the gas film resistance to evaporation from a solid or liquid surface. The analysis correctly predicts that surface resistance is negligible for practical problems. Reviewer finds it unfortunate that paper ignores most of the literature on this subject, such as P. V. Danckwerts [*Research* **2**, p. 294, 1949 and *Ind. Engng. Chem.* **43**, p. 1460, 1951] and R. Higbie, [*Trans. Amer. Inst. Chem. Engrs.* **31**, p. 65, 1935]. The recent paper of L. E. Scriven and R. L. Pigford [*AIChE J.* **4**, p. 439, 1958] describes an interesting study leading to the same conclusion for the  $\text{CO}_2$ -water system, and cites many of the other references in the field.

R. R. Hughes, USA

**3601. Lykov, A. V., and Smirnov, M. S., Investigating the kinetics of drying processes** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 10-19, Aug. 1956.

Author considers steady and unsteady drying processes of capillary-porous wet materials. After deriving the differential equations of heat and mass transfer for such a system, author introduces certain simplifications. In particular he shows that the equation of heat transfer of the Fourier-Kirchhoff type can be simplified to one of the Fourier type with sources and sinks. He proceeds to solve these equations for an infinite plate.

Y. R. Mayhew, England

3602. Gosse, J., Experimental study of thermal diffusivity of air in turbulent flow in a tube (in French), *C. R. Acad. Sci. Paris* **246**, 4, 552-554, Jan. 1958.

3603. Chanu, J., Note on the definition of diffusion coefficient in binary mixtures (in French), *C. R. Acad. Sci. Paris* **245**, 8, 829-831, Aug. 1957.

## Combustion

(See also Revs. 3508, 3595, 3622)

3604. Gross, D., and Robertson, A. F., Self-ignition temperatures of materials from kinetic-reaction data, *J. Res. Nat. Bur. Stands.* **61**, 5, 413-417, Nov. 1958.

Results of experimental determinations of the kinetic constants of the self-heating reaction are presented for wood fiberboard, cotton linters, sugar pine, cork, crepe rubber, GRS rubber, natural, synthetic, and blended foam rubber (with and without additive), various oils (raw linseed, cottonseed, rapeseed, sperm, olive, castor, and neatsfoot) applied to cotton gauze in a ratio of 1 part of oil to 6 parts of cotton by weight, ammonium perchlorate, and nitrocellulose plastic. Under the assumption that self-heating follows a first-order reaction, these constants were used to calculate the critical radii of spherical piles for each of four surface temperatures likely to be experienced in long-period storage. Calculated self-ignition temperatures of piles of  $\frac{1}{8}$ -inch-diameter to 22-inch-diameter spheres of wood fiberboard and  $\frac{1}{8}$ -inch-diameter to 2-inch-diameter spheres of cotton linters were in reasonable agreement with previous measurements by N. D. Mitchell [*National Fire Protection Association Quarterly* **45**, p. 162, 1951].

From authors' summary

3605. Jones, H., Accelerated flames and detonation in gases, *Proc. Roy. Soc. Lond. (A)* **248**, 1254, 333-349, Nov. 1958.

The gas dynamics of an accelerated flame proceeding into a gas initially at rest and starting from the closed end of a tube are discussed from the point of view of a particular accelerated flame model. The flame model assumes that the absolute flame velocity is a fixed fraction of the absolute particle velocity immediately in front of the flame. For two particular cases, one of constant flame acceleration, and the other of a flame acceleration increasing linearly with time, the gas motion and thermodynamic properties, both ahead of and behind the flame, are determined. The location of the point of formation of a shock wave in advance of the flame is also determined. Because of the model assumed, the heat release in the flame front is not constant, but is determined from the solution. A discussion is given concerning the relation of such solutions to the formation of a detonation wave from a flame front in a closed tube. A calculation is also made of the properties of a detonation wave, and it is inferred from comparison with experiment that complete reaction may not always occur in the accelerated flame.

J. A. Fay, USA

3606. Hirschfelder, J. O., McCone, A., Jr., and Odell, T., Elementary treatment of laminar flame propagation, Univ. Wis., Dept. Chem., Naval Res. Lab. CN-934 (NOrd 15884, Series 8), 59 pp., Aug. 1958.

The basic principles of flame propagation are considered in terms of highly idealized systems. The various factors which determine the flame velocity,  $v_0$ , as well as the profiles of temperature and chemical composition through the combustion wave, are explained.

S. S. Penner, USA

3607. Traustel, S., On the length of the diffusion flame with gaseous and atomized liquid and solid fuels (in German), *Brennstoff-Wärme-Kraft* **10**, 8, 367-369, Aug. 1958.

An analysis is presented of the length of laminar and turbulent flames involving gases and suspensions of liquid or solid particles in gas. The starting point is based upon Schlichting's treatment of boundary flows, and results obtained indicate a linear increase in flame lengths with approach velocity in the laminar region followed by a flame length which is independent of such velocity in the turbulent regime. This behavior is in agreement with experiment. The approach is straightforward and conventional. The inclusion of the treatment of the combustion of drops and solid particles involves a number of supplemental assumptions not usually encountered in such developments.

B. H. Sage and E. Peterli, USA

3608. Miller, A. B., Capella, A., and Spalding, D. B., Research on study of the turbulent flame properties of elementary combustion chamber flow patterns, AFOSR TN 58-388, (Tiltman Langley Ltd. TN 1; ASTIA AD 154 296), 44 pp., Feb. 1958.

3609. Blinov, V. I., Combustion in laminar flow of liquids in containers (in Russian), *Trudi Leningr. In-ta Aviats. Priborostr.* no. 14, 3-12, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11333.

This is an experimental investigation of the combustion in laminar flow of ethyl, butyl and iso-amyl alcohols and benzene in glass and metallic burners, to implement the data and clarify the remaining unsolved questions relating to the theory of liquids in containers. The deductions made as the result of the analysis of the tests were as follows: 1) it is established that for a given liquid the relation between the quantity of liquid burnt and the height of the flame remains a constant value, not depending on the diameter, material of the burner and of the level of liquid in it; 2) the rapidity of burning of benzene is higher than the rate of burning of the alcohols because of the greater emissive power of the flame; 3) the decrease in the rapidity of burning with the increase of diameter is explained by the reduction in heat losses through the walls of the burner; 4) the rate of burning in metallic burners is somewhat lower than in glass ones because of large losses of heat into the surrounding medium through the wall; 5) in the tests some difference was observed from the theoretical formula of laminar combustion:  $\rho M/\delta = \text{const}$ ,  $\beta$  is the coefficient calculated to equal the number of grams of oxygen required for the combustion of 1 gram of gaseous vapour;  $\mu$  is the number of grams of liquid burnt in a unit of time; and  $\delta$  is the height of the flame. It is assumed that the difference is due to different degrees of completeness of combustion of the liquids under observation when being tested, and that consequently a corresponding correction factor should be introduced to get better agreement with the formula.

M. V. Krasnogladyadova

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3610. Fine, B. D., A study of oxidation of hydrogen based on flashback of hydrogen-oxygen-nitrogen burner flames, *NASA Memo.* 12-23-58E, 20 pp. + 2 tables + 6 figs., Jan. 1959.

The flashback of hydrogen-oxygen-nitrogen flames was measured at reduced pressures as a function of burner diameter, pressure, and mixture composition. On the assumption that the critical boundary velocity gradient for flashback is a measure of the mean reaction time within a flame, the data were used to evaluate parameters in the rate expression for the flame reaction. The reaction order with respect to oxygen was about 0.9 and that for hydrogen was about 1.4, independent of flame temperature. The dependence of the specific rate constant, for which values were estimated, on flame temperature could not be described by a constant activation energy.

From author's summary

3611. Denison, M. R., and Dooley, D. A., Combustion in the laminar boundary layer of chemically active sublimating surfaces, *J. Aero. Sci.* **25**, 4, 271-272, Apr. 1958.

A detailed analysis is carried out on the heat and mass transfer from sublimating surfaces in a high-temperature air stream. The analysis is of obvious interest to the behavior of reentry bodies, which are composed of combustible materials such as graphite, in the treatment of combustion in a hypersonic boundary layer, in which the combustion rate is aerodynamically limited, and provides the basic explanation for the desirable reentry characteristics of a combustible reentry body. The usual simplifications resulting from the assumption of unit Prandtl and Lewis numbers provides a simplified yet valid interpretation of the governing processes. Interestingly enough, a detailed knowledge of the chemical kinetics is not required. D. Altman, USA

**3612. Andersen, W. H., and Chaiken, R. F., Application of surface decomposition kinetics to detonation of ammonium nitrate, ARS J. 29, 1, 49-51 (Tech. Notes), Jan. 1959.**

Kinetic rate data for the linear surface gasification (pyrolysis) of ammonium nitrate are used in conjunction with the Eyring grain burning theory to calculate the detonation reaction time for ammonium nitrate. A new grain burning mechanism is postulated which results in a reaction time for detonating ammonium nitrate which is consistent with that calculated by means of the nozzle and curved-front diameter theories. The possible implications of the new model with respect to low velocity detonation in mixtures of granular explosives are discussed.

From authors' summary

**3613. Hibbard, R. R., and Evans, A., Application of gas analysis to combustor research, NASA Memo. 1-26-59E, 14 pp. + 4 tables + 3 figs., Feb. 1959.**

Gas analysis has been studied as a means for determining the performance of turbojet and ramjet combustors. Samples taken at the outlet of a production-model turbojet combustor operating over a range of conditions gave efficiencies which, in general, agreed with those determined by bare-junction thermocouples. Samples taken at the outlet and at two upstream stations were used to calculate local fuel-air ratios, efficiencies, and heat-release rates. These data and those taken from two ramjet combustors permit estimates to be made of the nature of the rate-limiting processes in the practical combustion of hydrocarbons in air. It was found that kinetic processes are rate-limiting at low pressures and physical processes are rate-controlling at high pressures.

From authors' summary

**3614. Clark, B. J., Hersch, M., and Priem, R. J., Propellant vaporization as a criterion for rocket-engine design; experimental performance, vaporization, and heat-transfer rates with various propellant combinations, NASA Memo. 12-29-58E, 16 pp. + 3 tables + 8 figs., Jan. 1959.**

Experimental combustion efficiencies of 11 different propellant combinations were determined in a nominal 200-pound-thrust rocket engine at three chamber lengths. The experimental data were compared with analytical results based on the assumption that vaporization of the propellants determines the combustion rate. The data agreed with the predicted results except for hydrazine, which may have decomposed in the liquid phase, and ammonia-fluorine. Measured overall heat-transfer rates compared well with values predicted by standard heat-transfer calculations except for combinations using ammonia.

From authors' summary

**3615. Whitney, G. C., Use of models for studying pulverized-coal burner performance, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958, Pap. 58-A-95, 3 pp.**

**3616. Thurlow, G. G., Paris conference on combustion of solid and pulverised fuels—Dec. 1957, Combustion 30, 3, 53-57, Sept. 1958.**

**3617. Spalding, D. B., Approximate solutions of transient and two-dimensional flame phenomena: constant-enthalpy flames, Proc. Roy. Soc. Lond. (A) 245, 1242, 352-372, June 1958.**

Paper provides an interesting approximate means of predicting certain transient flame phenomena using the profile methods of boundary-layer theory. The work is restricted to simplified combustion systems occurring under adiabatic conditions, and in all cases it is assumed that the volumetric reaction rate depends only on the temperature. Four types of flame phenomena are examined:

- (a) The events occurring when a large mass of cold unreacted gas comes in contact with a large mass of hot burnt gas.
  - (b) Flame propagation caused by the contact of a solid catalyst "sheet" with a large mass of unburnt gas.
  - (c) Flame propagation in a slab of unreacted gas mixture immersed in a much larger mass of hot burnt gas.
  - (d) Flame propagation from a hot pocket of reacted gas immersed in a large mass of cold unreacted fuel/oxidant mixture. This is of particular interest in the spark ignition of gases and in the use of pilot flames to promote combustion in present fuel/oxidant system.
- The general conclusion appears to be that profile methods provide relatively easy methods of obtaining approximate solutions of certain flame phenomena. The accuracy of this method is stated to be about 20%. A. H. Howland, England

**3618. Clarke, J. S., and Lardge, H. E., The performance and reliability of aero-gas-turbine combustion chambers, Trans. ASME 80, 8, 1741-1755, Nov. 1958.**

## Prime Movers and Propulsion Devices

(See also Revs. 3279, 3612, 3614)

**3619. Griffin, D. N., Turner, C. F., and Angeloff, G. T., A ballistic bomb method for determining the experimental performance of rocket propellants, ARS J. 29, 1, 15-19, Jan. 1959.**

A method has been devised for the determination of measured performance values of rocket propellants without the requirement of actual rocket motor operation. Constant-volume combustion in a ballistic bomb will provide accurate data on the impetus  $(nRT)_v$  of a propellant system. By an approximation method  $(nRT)_v$  is converted to  $(nRT)_p$ , from which term characteristic velocity  $(C^*)$ , and hence specific impulse  $(I_{sp})$ , can be derived. Since an impetus value can be obtained with as little as 50 to 100 gm of propellant, the ballistic bomb method allows performance evaluation at an early stage when only limited quantities of a new propellant are available.

From authors' summary

**3620. Salzman, J., Solids give liquids a boost, Astronautics 3, 10, 30-32, Oct. 1958.**

Compact and mechanically simple, solid-propellant gas generators offer an alternative to high-pressure bottles or liquid-propellant generators for pressurizing liquid-propellant rocket motors.

From author's summary

**Book—3621. Stetchkin, B. S., Kazandjan, P. K., Alexeyev, L. P., Govorov, A. N., Netchayev, Yu. N., and Fedorov, R. M., Theory of jet engines; bladed engines; A textbook for aeronautical engineering colleges (in Russian), Moscow, Oborongiz, 1956, 548 pp. + illus.; Ref. Zh. Mekh. no. 8, 1957, Rev. 8869.**

**3622. Weber, R. J., and MacKay, J. S., An analysis of ramjet engines using supersonic combustion, NACA TN 4386, 23 pp. + 1 table + 24 figs., Sept. 1958.**

An analysis of thrust and overall engine efficiency is given for ramjet engines with shock-free internal combustion, presupposing the latter is possible. Flight Mach numbers between 4 and 7 are

considered with three types of inlet: pitot, wedge and isentropic. Compared to a conventional ramjet engine with diffusion to Mach 0.175 before combustion, the supersonic type with wedge inlet is more efficient above Mach 7; with isentropic inlet more efficient above Mach 5; and with pitot inlet less efficient at all speeds. Effects of nozzle efficiency and expansion ratio, combustor area variation, wall friction, cooling and dissociation are considered. No weight advantage is seen.

D. G. Shepherd, USA

**3623. Beeton, A. B. P., A simplified method for estimating the performance of supersonic ram-jets, *Aero. Quart.* 9, 3, 195-212, Aug. 1958.**

Curves are presented which, together with a knowledge of the intake performance, enable ramjet thrust coefficients and specific consumption figures to be obtained quickly and accurately in the range  $M = 1.0$  to  $3.0$ .

From author's summary

**3624. Bartz, D. R., Factors which influence the suitability of liquid propellants as rocket motor regenerative coolants, *Jet Propulsion* 28, 1, 46-53, Jan. 1958.**

A brief review of methods of utilizing liquid propellants as rocket-motor coolants is given, and criteria for acceptable cooling are established. Methods of analytical and experimental determination of the pertinent heat-transfer characteristics of propellants are described. The measured maximum rates at which liquid ammonia can satisfactorily accept heat are presented to show typical trends with variations of fluid pressure, temperature and velocity. Measured maximum rates for several propellants are compared with predictions of heat fluxes from the combustion gases of these propellants when producing the same thrust in a hypothetical rocket motor. From this comparison, an insight into the importance of various propellant properties and operating conditions is gained.

From author's summary

**3625. Guerin, J. T., Carroll, J. G., Bolt, R. O., and Bert, J. A., Nuclear radiation and the thermal stability of jet fuels, *Aero/Space Engng.* 18, 1, 27-31, Jan. 1959.**

Hydrogen and hydrocarbon fragments evolve and olefins and polymers form when jet fuels are exposed to nuclear radiation. These changes will affect the use of jet fuels in nuclear environments.

From authors' summary

**3626. Cotter, T. P., Potentialities and problems of nuclear rocket propulsion, *Aero/Space Engng.* 18, 2, 50-54, Feb. 1959.**

**3627. Willinski, M. I., and Orr, Elsie C., Project Snooper, a program for unmanned interplanetary reconnaissance, *Jet Propulsion* 28, 11, 723-728, Nov. 1958.**

Design of unmanned nonreturn low-cost interplanetary reconnaissance vehicle is described. Vehicle, boosted into initial orbit by conventional rocket booster, is ion-propelled. An unshielded 1-megawatt (thermal) sodium-cooled nuclear reactor is the primary power source. A mercury turbine drives the electrical generator (147 kw). Details of the cesium ion propulsion system are discussed. System provides for acceleration of 0.1 milligee. Total vehicle weight is 3300 lb. During the time that the vehicle is performing its information-gathering and data-transmitting task, the propulsion system is not operating and the useful power is consumed by the electronic payload. The weight statement is consistent with those for similar, larger designs which have been published (see, e.g., NASA Memo. 2-20-59E).

W. Daskin, USA

**3628. Free, B. A., and Sarner, S. F., A rapid method for estimation of specific impulse, *ARS J.* 29, 1, 64-67 (Tech. Notes), Jan. 1959.**

A semiempirical method for rapid estimation of specific impulse of rocket propellant systems is presented, based on a simplifica-

tion of standard thermodynamic equations and the use of suitable reference systems. The accuracy of the method is of the order of  $\pm 3\%$  in most cases, with an extreme range of  $\pm 5\%$ . Within this range, systems which produce high flame temperatures, or high degrees of dissociation, and those which involve large amounts of monatomic or tetratomic products deviate, in general, more than the conventional systems.

From authors' summary

**3629. Dixon, T. F., Prophecy for propulsion—one man's guess, *Aero/Space Engng.* 18, 2, 35-40, Feb. 1959.**

## Magneto-fluid-dynamics

**3630. Gross, R. A., A note on one-dimensional plasma motion, *J. Aero/Space Sci.* 25, 12, 788-789 (Readers' Forum), Dec. 1958.**

Author derives the change of a number of physical quantities from the magnetohydrodynamic equations, as a function of heat added during the motion. He shows that the behavior is characteristically different depending on whether a generalized Mach number (taking into account the magnetic effects upon the propagation of disturbances) is larger or smaller than unity.

W. M. Elsasser, USA

**3631. Bleviss, Z. O., Magnetogasdynamics of hypersonic Couette flow, *J. Aero/Space Sci.* 25, 10, 601-615, Oct. 1958.**

Author investigates the problem of plane Couette flow produced when a viscous and electrically conducting gas contained between two infinitely extended plane walls normal to a uniform external magnetic field is set into motion by the relative movement of walls in their own plane. Assuming thermodynamic equilibrium and reasonable variations of electrical conductivity, viscosity, and Prandtl number with temperature, numerical solutions are presented for air for the case of insulated wall and for the case of heat transfer for Mach numbers of 20 and 30. The effects of magnetic field upon velocity, temperature, current density and induced magnetic field distributions and upon skin friction, heat transfer and total drag are shown.

The results show that relatively weak magnetic fields produce large increases in total drag, large reductions in skin friction, and at the same time have little effect on heat transfer. Author shows also that with magnetic field total drag is primarily magnetic drag.

Y. H. Kuo, China

**3632. Berger, J. M., Newcomb, W. A., Dawson, J. M., Frieman, E. A., Kulsrud, R. M., and Lenard, A., Heating of a confined plasma by oscillating electromagnetic fields, *Phys. Fluids* 1, 4, 301-307, July-Aug. 1958.**

A columnar plasma confined by a strong, axial magnetic field may be heated under the influence of either a paraxial electric field, the case called ohmic heating, or under an electric field produced perpendicular to the magnetic field axis by an externally imposed oscillation of the magnetic field, the case called magnetic pumping. Authors consider four limiting sub-cases of this latter type, determined by the relative sizes of four characteristic times, viz., (1) collision time, (2) period of the oscillating field, (3) transit time of a typical ion through the pumping region, and (4) the cyclotron period of an ion. Approximate mathematical treatments of four types called collisional, transit time, acoustic and ion cyclotron resonance heating are outlined and energy flux formulas discussed. Subject to certain qualifications, the four types of heating are increasingly efficient in the order just given as temperature increases. Randomization of energy of organized wave motion in a plasma is considered to occur because of mixing of various parts of the wave because of random thermal velocities. While this process does not result immediately in a Maxwellian distribution, subsequent collisional processes are believed to be more effective.

F. D. Bennett, USA

3633. Rossow, V. J., On flow of electrically conducting fluids over a flat plate in the presence of a transverse magnetic field, *NACA Rep.* 1358, 20 pp., 1958.  
See AMR 10 (1957), Rev. 4104.

3634. Kantrowitz, A., Introducing magnetohydrodynamics, *Astronautics* 3, 10, 18-21, Oct. 1958.

3635. 30,000 degrees with the plasma jet, *J. Metals* 11, 1, 40-42, Jan. 1959.

Expanding the frontiers of high-temperature, two US firms recently have announced the development of plasma-type torches capable of producing a jet of electrically neutral, partially ionized gas at extremely high temperatures. The result is a radically new method for fabricating shapes and applying coatings that will withstand temperatures above 5000 F.

From summary

## Aeroelasticity

(See also Revs. 3324, 3458, 3522).

3636. Hains, F. D., Flutter of a thin membrane in hypersonic flow, *J. Aero/Space Sci.* 25, 9, 595-596 (Readers' Forum), Sept. 1958.

3637. Li, T., Influence of internal pressure and supersonic potential flow on the frequencies of thin, finite, cylindrical shells (in English), 9th Congrès Intern. Mecan. Appl. 1957; 2, 199-210.

Author investigates the vibrations of an internally pressurized finite circular cylinder in an air stream moving at supersonic speed in the direction of the shell longitudinal axis. Epstein-Kennard cylinder equations are used to describe shell deformations and linearized potential flow theory for the air stream. The boundary conditions at the ends of the cylinder are somewhat obscure and the theory for cylinder in air is very likely applicable only to an infinitely long cylinder. No numerical results are given and implications of equations are uninvestigated. Author conjectures that frequencies under aerodynamic forces are somewhat lower than those of free vibrations. Several of the equations are mislabeled in the text.

An approximation is given for frequencies of free vibration in vacuo which gives results qualitatively similar to those obtained by Fung, Sechler, and Kaplan ["On the vibration of thin cylindrical shells under internal pressure," *J. Aero. Sci.* 24, 9, 650-660, Sept. 1957; AMR 11 (1958), Rev. 766] in that two roots of the frequency equation are unaffected by pressure, whereas the third root varies significantly with increasing pressure. Author, however, does not identify these roots as being associated with predominantly tangential motions and radial motion, respectively.

A statement is made that "the inclusion of second-degree thickness terms . . . results in possible damping factors, particularly for higher modes." It is difficult to understand how a theory which assumes purely elastic behavior could possibly yield damped vibrations for the cylinder in vacuo. Author does not show this to be so and, indeed, Fung et al show that a previous investigation by E. Reissner ["Notes on vibrations of thin pressurized cylindrical shells," *Aeromechanics Rept.* AM 5-4, Ramo-Woolbridge Corp., Nov. 1955], which assumes membrane theory for the cylinder, yields frequency results with 7% of exact values for circumferential wave numbers as low as 2 and almost indistinguishable results for wave numbers larger than 3 or 4. For vibrations in air or water, Bleich and Baron ["Free and forced vibrations of an infinitely long cylindrical shell in an infinite acoustic medium," *J. Appl. Mech.* 21, 2, 167-177, June 1954; AMR 7 (1954), Revs. 1301, 3132] discuss the possibility of damping due to the acoustic medium. It would appear that this damping would be obtained even if membrane theory were used for the cylinder.

P. Seide, USA

3838. Papadopoulos, J. G., Aeroelastic solution for a wing plan form with a tip control surface, *J. Aero/Space Sci.* 25, 11, 726-727 (Readers' Forum), Nov. 1958.

An earlier method of Brown, Holtby and Martin [AMR 5 (1952), Rev. 846] is extended to include the case of an all-movable wing tip. Cubic approximations to twist are applied separately in the fixed and movable portions of the wing span.

G. Isakson, USA

3639. Taylor, J. L., Natural vibration frequencies of flexible rotor blades, *Aircr. Engng.* 30, 357, p. 331, Nov. 1958.

Author solves the basic differential equation of flapwise blade bending by omitting structural stiffness terms. Power-series solutions of blade natural frequencies are obtained for the case of uniform-mass blades and for blades having mass distributions that vary uniformly from a maximum at root to zero at tip. Analysis is primarily of academic interest because solutions apply only to range of rotational speeds wherein centrifugal-force stiffness is large compared to structural stiffness. For practical applications, published literature contains many analyses, such as the Southwell approach, that yield solutions over entire range of frequencies and modes.

A. Gessow, USA

3640. Jones, J. P., The influence of the wake on the flutter and vibration of rotor blades, *Aero. Quart.* 9, 3, 258-286, Aug. 1958.

A theory is described which takes into account the influence of the wake on the aerodynamic derivatives of an oscillating rotor blade. It is shown that the most important parameter is the number of cycles of the oscillation which occur during one revolution of the rotor. For integral values of this parameter the flexural damping is shown to become very small at small angles of incidence. The flutter characteristics of a simple rotor blade are calculated on the basis of this theory, and it is found that the wake causes radical changes in the critical speeds. The theory is in good qualitative agreement with experiment.

From author's summary by A. Gessow, USA

3641. Singh, B. R., and Pearce, C. E., On some problems of wind-induced vibration, *J. Aero. Soc. India* 10, 2, 28-35, May 1958.

Vibrations resulting from aerodynamic instability are generally complex in nature and may have serious effects. They may destroy the vibrating member through fatigue, or at least impair its usefulness. This paper analyzes the entire situation in regard to the principles involved, as related to problems of wind-induced vibration of smoke-stacks, suspension pipe-lines, bridges, electric transmission lines, etc. Particular reference is made to the forced vibration effects and to the dampers and absorbers employed to control some of the vibrating systems.

From authors' summary

3642. Holder, D. W., and Pearcey, H. H., A method for providing warning of the onset of buffeting, stalling, and other undesirable effects of flow separation, *J. Roy. Aero. Soc.* 62, 573, 674-676 (Tech. Notes), Sept. 1958.

## Aeronautics

(See also Revs. 3325, 3518, 3640)

3643. Wagner, F. C., Design considerations for BLC STOL airplanes, *Aero/Space Engng.* 17, 10, 58-64, Oct. 1958.

3644. Nonweiler, T. R. F., The man-powered aircraft—a design study, *J. Roy. Aero. Soc.* 62, 574, 723-734, Oct. 1958.

An appreciation is made of recent experimental and project work of relevance to the design of a very light-weight aircraft capable

of being taken off and flown by two men. The emphasis is on the aerodynamic problems involved. It is concluded that, although there are many difficulties still needing attention, all the information supports previous assertions that flight by muscular power alone is possible. The merits and de-merits of a particular projected design are studied, and its performance and stability assessed.

From author's summary

## Astronautics

(See also Revs. 3214, 3392, 3594, 3612, 3619, 3627, 3654)

**Book—3645. Shternfeld, A., Artificial satellites** (Translation of *Iskusstvennyye Sputniki*), 2nd revised and extended ed., Washington 25, D. C., OTS (PB 141 351T), 1958, vii + 242 pp. \$6. (Paperbound)

Author, winner of the International Prize for the Promotion of Astronautics, presents an unusually complete picture of the state of the art, combining the important results of the many articles in the various publications all over the world with his own significant research. Remarkable are the 51 tables, mostly author's original contributions, and some of his ideas such as those on indirect trajectories. This up-to-date second revised and extended edition, written after the launching of Sputnik II, devotes major space to celestial mechanics and rocketry, relegating remote control, communications, and physiology to secondary place, but integrates all aspects into a logically built-up system. The book is written in fluent style which can in principle be understood by the educated layman, especially if he skips over certain, more difficult portions which supposedly have been printed in small type (for technical reasons, the translation shows no difference); however, the graduate engineer and the reader with technical background will get real benefit from the book. Although without mathematical formulas, the book actually requires a full understanding at least of Kepler's laws and propulsion principles. Reviewer believes that the book would be still more valuable if the mathematical foundations had been given in small print or in an appendix.

The Table of Contents shows 11 chapters: I-The laws of motion of artificial satellites; II-Motion of the satellite relative to an observer on earth (Synodical period); III-The rocket starter of the artificial satellite; IV-Launching of an artificial satellite; V-Construction of artificial satellites; VI-Man in cosmic space; VII-On board an artificial satellite; VIII-Observation of artificial satellites and their communication with the ground; IX-The descent to the earth; X-Artificial satellites of bodies of the solar system; XI-The utilization of artificial satellites. An appendix deals with astronomical societies, congresses, conferences, and their publications, also with the legal aspects of territorial rights to space.

Reviewer considers this book as most valuable due to its comprehensiveness, its numerous graphs, the simple comparisons which are given for better understanding of physical phenomena, the clear explanation of every new term in foot notes, and the purely scientific approach which gives full credit to the contributions of all nations (at one place, author slips and briefly discusses military applications from a political viewpoint, mentioning "the United States and other capitalist countries"). Reviewer did not see the original text but the translation sounds excellent. There are hardly any typographical errors. Reviewer considers as shortcomings that neither a complete list of references nor a subject index is given and that photographic illustrations are very poorly reproduced, evidently a shortcoming due to the printing process of the translation. The unusual spelling of names such as Shternfel'd should have been avoided—this does not contribute to a more correct pronunciation of the Russian letter l.

An edition of the translation in book form is recommended.

G. R. Graetzer, USA

**3646. Adams, J. J., and Chilton, R. G., A weight comparison of several attitude controls for satellites**, NASA Memo. 12-30-58L, 14 pp. + 5 figs., Feb. 1959.

A brief theoretical study has been made for the purpose of estimating and comparing the weight of three different types of controls that can be used to change the attitude of a satellite; namely, jet reaction, inertia wheel, and a magnetic bar which interacts with the magnetic field of the earth. The results show that the inertia-wheel system offers weight-saving possibilities if a large number of cycles of operation are required, whereas the jet system would be preferred for a limited number of cycles.

From authors' summary

**3647. Larmore, L., Celestial observations for space navigation**, *Aero/Space Engng.* 18, 1, 37-42, Jan. 1959.

The motions of the planets can serve as a measure of time and an accurate clock is thus not always required. Application of the principles involved is shown to yield useful check points for the purpose of correcting inaccuracies inherent in a purely ballistic system.

From author's summary

**3648. Nielsen, J. N., Goodwin, F. K., and Mersman, W. A., Three-dimensional orbits of earth satellites including effect of earth oblateness and atmospheric rotation**, NASA Memo. 12-4-58A, 52 pp. + 3 tables + 12 figs., Dec. 1958.

General equations are presented, useful for calculating complete trajectories of Earth satellites from outer space to the ground, under the influence of air drag and gravity. The effects due to the oblateness and the atmospheric rotation are included. The equations are applied to several cases of re-entry trajectories starting from a circular orbit.

In the first illustrative example, equatorial orbits are investigated. It is found that the loss of altitude per revolution is slightly influenced by the atmospheric rotation, but considerably influenced by the Earth's oblateness.

In the second illustrative example, the final revolution is calculated for a number of trajectories lying in a plane inclined at 65° with respect to the equatorial plane. In a typical case, it is found that oblateness has an influence of about 300 miles on the impact point, while atmospheric rotation has an influence of about 150 miles.

A. Miele, USA

**3649. Gedeon, G. S., and Dawley, R. E., The influence of the launching conditions on the orbital characteristics**, *Jet Propulsion* 28, 11, 759-760 (Tech. Notes), Nov. 1958.

Authors calculate, in terms of the burnout condition, the apogee and perigee altitudes of a satellite orbit in vacuum around a spherical nonrotating Earth. Solutions are given in the form of nomograms for converting burnout velocity and altitude into velocity ratio and for converting radius ratio and burnout altitude into apogee and perigee altitudes. The conclusions reached are essentially those given by Singer, *Astronautica Acta*, Vol. II, 1956.

R. W. Detra, USA

**3650. Hord, R. A., Relative motion in the terminal phase of interception of a satellite or a ballistic missile**, NACA TN 4399, 22 pp. + 1 table + 10 figs., Sept. 1958.

Destructive interception of aircraft has been well developed in the past; corresponding analysis of the interception of satellites and ballistic missiles is virtually nonexistent. Author has been concerned with the feasibility of two types of interception: (1) the terminal relative approach speed is small compared with the target speed (overtaking interception), which has been found to be feasible; and (2) head-on interception with mass dispersal before impact. The conclusions for (2) are much more difficult to assess since approximations indicate that the required mass is of the same order of magnitude as the target mass.

Interception of a satellite poses two essentially new features: (1) predictability of the orbit over large distances and times so that in-flight corrections can be kept small; and (2) the high speeds of the target. F. V. Pohle, USA

**3651. Carrara, N., Checcacci, P. F., and Ronchi, Laura, Determination of the trajectory of an artificial earth satellite (in Italian), *Ric. Sci.* 28, 7, 1341-1355, July 1958.**

Authors derive formulas for obtaining certain parameters of the local path of an artificial satellite from Doppler data, assuming a known satellite transmitter frequency and an ignorable distortion due to the atmospheric refraction. Depending on the case, these parameters are velocity, minimum distance to observing stations, and Cartesian coordinates of the satellite. Authors treat the following cases: single receiver and rectilinear constant velocity of the satellite; single receiver and circular orbit to give an estimate of the errors made by the rectilinear assumption; three receiving stations and general orbit with minimum distances approximated from locally rectilinear assumptions; and finally, four receivers on a square and general orbit with no geometric assumptions on the orbit including earth's rotation. All formulas are amenable to numerical computation. The paper concludes with considerations, a brief description, and block diagrams of a possible logical organization of the receiving apparatus.

M. L. Juncosa, USA

**3652. Poppoff, I. G., Low-cost meteorological rocket systems, *Astronautics* 3, 10, 26-28, Oct. 1958.**

Development of simple, practical systems of the type described here, in which expendable equipment could be held to about \$155 per firing, would prove mutually beneficial to both meteorology and rocketry. From author's summary

## Ballistics, Explosions

(See also Rev. 3619)

**3653. Roth-Desmeules, E., On the representation of trajectories and their perturbations for fire control instruments (in German), *ZAMP* 9a, 3, 235-250, Sept. 1958.**

Author develops an approximate representation of the position vector for the point of impact between target and projectile. Approximation is obtained through combination of separated functions of pertinent parameters by means of the fundamental operations of addition, subtraction and multiplication. Method is critically investigated for the simple case of a resistance law which is a linear function of velocity. Some of the derived results might have been obtained also by simple physical reasoning on the basis of the simplified assumptions. F. W. Wendt, USA

**3654. Struble, F. A., Stewart, C. E., and Granton, J., Jr., The trajectory of a rocket with thrust, *Jet Propulsion* 28, 7, 472-478, July 1958.**

Two-dimensional powered flight rocket equations are expressed in terms of speed as independent variable; mass and path angle as dependent variables; thrust, drag and mass rate as parameters. It is assumed that the thrust is in the direction of the velocity vector.

Equations are integrated in closed form under the assumption that the thrust is high compared to the gravity force, and that the drag is proportional to the square of the speed (implying among other things that the total altitude variation is small). For cases in which these assumptions are not applicable, paper includes auxiliary functions and graphs to assist numerical integration.

Because of the restrictive assumptions, reviewer feels that application is limited to small-caliber finned rockets.

J. Lorell, USA

**3655. Cook, M. A., and Keyes, R. T., Generation of high-velocity projectiles, *J. Appl. Phys.* 29, 12, 1651-1656, Dec. 1958.**

A technique of controlling the shape of detonation wave fronts in high explosives by inert wave control inserts was applied to generate discrete ultrahigh-velocity pellets. Tests to determine the most suitable pellet shape as well as the optimum charge configuration are described, and velocities up to 7600 m/sec were realized for 0.95-g aluminum pellets. The mechanism whereby pellets are accelerated by "shaped" waves is discussed, and the conclusion is reached that a simple model based upon the transmission of shock from the detonation wave to the pellet is not applicable. From authors' summary

## Acoustics

(See also Rev. 3387)

**3656. Gibson, W. E., and Moore, F. K., Acoustic propagation in a diatomic gas subject to thermal or chemical relaxation, AFOSR TN 58-1057 (Cornell Aero. Lab., Inc., Rep. No. HG-1956-A-2; ASTIA AD 206 988), 52 pp. + 9 figs., Dec. 1958.**

A theory of acoustic propagation in a gas subject to relaxation phenomena is presented. In most applications of the theory to diatomic gases, only one degree of freedom need be considered, all the others being either frozen or in equilibrium. An acoustic equation is obtained herein for small disturbances from an equilibrium state of rest; this equation applies equally well to unsteady one-dimensional waves or to steady two-dimensional disturbances.

The problem of two-dimensional airfoil in a supersonic flow of relaxing gas is considered. From the acoustic equation, the law of decay of shock waves and the values of the flow properties on the surface of the airfoil are derived. Furthermore, the asymptotic behavior of the flow field is obtained far from the airfoil so that the formation of an equilibrium wave is described.

The acoustic equation involves the two wave operators which can be defined on the basis of the frozen and equilibrium sound speeds. The closeness of the sound speeds allows a simplification of the full equation to a variant of the telegraph equation. This approximate equation is uniquely determined by the requirements that the shock decay law and the exact value of the equilibrium sound speed be preserved. An explicit solution for the flow field is then presented and proved to be in close agreement with the exact solution on the surface of the airfoil and in the asymptotic range. A numerical example is given for a simple wedge. From authors' summary

**3657. Pancholy, M., and Atal, B. S., Sound absorbing properties of indigenous mineral wool, *J. Sci. Indust. Res., India*, 17B, 7, 239-241, July 1958.**

The sound absorption coefficient and specific acoustic impedance have been determined for a mineral wool of indigenous origin over the frequency range of 100-5000 c/s. This material compares favorably, in its sound absorbing properties, with imported varieties of rockwool, and could be utilized for sound insulation purposes. From authors' summary

**3658. Maglieri, D. J., and Hubbard, H. H., Preliminary measurements of the noise characteristics of some jet-augmented-flap configurations, *NASA Memo.* 12-4-58L, 10 pp. + 13 figs., Jan. 1959.**

Far-field noise characteristics of some proposed jet-flap configurations are presented in the form of noise radiation patterns and frequency spectra. The tests were conducted using cold-air jets of circular and rectangular exits having equal areas. The pressure ratio was such that the exit velocity was slightly below choking. The effect of changing nozzle geometry, flap length, flap deflec-

tion, and the effect of changes in the jet-mixing patterns on the noise radiation and frequency spectra are presented. A discussion of some possible implications of the data is also presented.

From authors' summary

**3659. Putnam, A. A., Flow-induced noise in heat exchangers,** ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958, Pap. 58-A-103, 4 pp.

**3660. Kamo, R., Suppression of engine-exhaust noise,** ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958, Pap. 58-A-144, 16 pp.

**Symposium on engine noise and noise suppression,** Instn. Mech. Engrs., Prepr., 46 pp., 1958.

**3661. Burns, W., Noise and hearing: physiological aspects,** 3-11.

**3662. King, A. J., Reduction of internal-combustion engine noise by enclosure,** 12-18.

**3663. Austen, A. E. W., and Friede, T., Origins of diesel engine noise,** 19-32.

**3664. Martin, W., Measurement of the noise of motor vehicles** 33-46.

**3665. Hirone, T., and Kamigaki, K., Attenuation of the ultrasonic waves in metals. II. Stainless steel** (in English), *Sci. Rep. Res. Inst., Tohoku Univ., Japan (A)* **10**, 4, 276-282, Aug. 1958.

Ultrasonic attenuation coefficients of stainless steel with various grain sizes were measured by pulse method at the frequencies ranging from 0.5 to 6 Mc/s. The stainless steel used was of austenite structure containing about 19% chromium and 10% nickel. It was found that the attenuation coefficient increased remarkably with the frequency, and that the increase was more rapid with increasing size of crystal grains. The nature of such an attenuation behavior was explained by assuming that the travelling ultrasonic waves are scattered by the austenite crystal grains in accordance with Rayleigh's law.

From authors' summary

**3666. Bergman, R. H., and Shahbender, R. A., Effect of statically applied stresses on the velocity of propagation of ultrasonic waves,** *J. Appl. Phys.* **29**, 12, 1736-1738, Dec. 1958.

Paper gives the results of an experimental investigation of the changes in the velocities of ultrasonic waves propagating transverse to the direction of applied stress in an aluminum column. The ultrasonic modes considered are longitudinal waves, shear waves with particle motion along the direction of applied stress, and shear waves with particle motion transverse to the direction of applied stress. The experimental results indicate that the relevant elastic constant for longitudinal waves is independent of stress, while that for the shear waves is stress dependent and also depends on the relative orientation of the particle motion and the direction of applied stress.

From authors' summary

**3667. Dantine, R., Propagation of shock waves and ultrasonic waves in elastic materials** (in French), *Bull. Centre Étude Constr. Genie Civ. Hyd. Fluviale* **9**, 185-189, 1957.

## Micromeritics

(See also Revs. 3383, 3482, 3654)

**3668. Null, H. E., and Johnson, H. F., Drop formation in liquid-liquid systems from single nozzles,** *AICbE J.* **4**, 3, 273-281, Sept. 1958.

Interfacial area is an important variable in mass-transfer operations. This paper represents a serious attempt to clarify some interfacial and flow phenomena of interest for processes involving liquid-liquid systems. In such systems, where interfacial area comprises drop surfaces, the area can be computed if drop sizes are known. This paper presents a new correlation which predicts volumes of drops formed from single nozzles to within 20% throughout the range of nozzle flow rates for which uniform drop sizes are obtained. Experimental apparatus is illustrated and described; it consists of a square stainless-steel column having two sides made of plate glass; the dispersed phase was admitted into the column through a nozzle. Sixteen nozzles having inside diameters varying between 0.169 and 0.460 in. were used. The flow was adjusted and the drops formed were observed and photographed in stroboscopic light. Empirical equations are set up between dimensionless quantities, and illustrated in charts, to express drop volumes for given flow rates.

K. J. DeJuhasz, Germany

**3669. Johnson, A. I., Hamielec, A., Ward, D., and Golding, A., End effect corrections in heat and mass transfer studies,** *Canad. J. Chem. Engng.* **36**, 5, 221-227, Oct. 1958.

Drops of liquid A rise or fall under gravity through another immiscible liquid B, and the drop motion is divided into three regions: (1) formation and acceleration; (2) steady motion; (3) coalescence and collection of drops to form a continuous A phase. Heat or mass is being transferred between the A and B phases.

The paper gives a method of estimating, from the measured overall transfer, the transfer during regions (1) and (3) and thereby deducing the transfer during steady motion. The method is to plot a function of the transfer against the contact time, assuming a constant end effect. The form of the function used is decided by known theoretical equations, and to apply these equations it must be known whether the resistance to transfer is inside or outside the drop, or in both phases, and whether circulation is taking place.

J. F. Davidson, England

**3670. Meyer, H., The drainage of rectilinear pulp table roll on a stationary foil** (in German), *ZVDI* **100**, 18, 773-777, June 1958.

The problem formulated by the title is treated on the basis of the differential equation for creeping motions and under the assumption of a laminar law of resistance. The results coincide qualitatively with some Canadian test data.

G. Herrmann, USA

**3671. Komarov, A. A., Means of increasing the efficacy of snow shields on transportation systems** (in Russian), *Problems of the utilisation of snow and combating snow drifts and avalanches*, Moscow, 1956, 120-153; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9195.

Results are presented of experimental investigations on snow-shields and other means of snow protection, conducted by the Transport and Power Institute of the West Siberian Branch of the Academy of Sciences of the USSR. A relationship is stated for the quantity of snow transported in relation to wind velocity, derived by D. M. Melnik [*Tekhnika Zheleznykh Dorog* no. 11, 1952]. The author of the present paper in collaboration with A. K. Dyumin puts forward a similar formula. The possibility is demonstrated of expressing the intensity of snow transportation by an empirical relationship founded on an evaluation of blizzard observations. On the basis of a study of the relationships in the transportation and deposition of snow, and on an analysis of the work and efficacy of snow-protection means, author develops the conditions for the design of properly constructed snow shields and like means.

Paper gives the results of investigations on the permeability of snow screens of different types made on models in a wind tunnel. Hence, from the experimental results, author concludes

(1) The most efficient constructions for protection against snow drifts are fence rows consisting of narrow fences (10-13 cm) with intervening gaps.

(2) The best form of snow shields is that having a perforated lower part with a permeability of up to 75% at the bottom and 50% at the top.

(3) Tests on light snow fences show greatest efficacy at 0.4H, H being the height of the fence, less the gap.

(4) Two types of two-row snow fences were tested in the wind tunnel: (a) both rows with increased permeability; (b) first fence on the field side with increased permeability; second row with 50% permeability. It was found that the most suitable permeability for the first fence was about 75%, while the distance between rows in either case could attain up to 30 times the fence height.

It is pointed out that the author's conclusions have been confirmed by field tests on snow fences on the Tomsk Railway.

E. E. Gurtovaya

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3672. Komarovskiy, A. A., Verteshev, M. S., and Streltsov, V. V., The hydraulic resistance of a layer of particles of arbitrary shape (in Russian), *Trudi Novocherkassk. Politekh. In-ta* 41, 55, 41-57, 1956; Ref. Zh. Mekh. no. 8, 1957, Rev. 9209.**

The resistance of a layer of particles of arbitrary shape is expressed by the resistance of a layer of spheres of equal size, by means of the so-called "stratification coefficient." A survey is made of numerous experiments on the resistance of a layer or stratum; the formulas derived by different authors are given in a uniform system of parameters.

Results are given of the present authors' experiments on the resistance of a layer consisting of aluminum cylinders (4 samples) and of sands with grain diameters of 0.45, 0.90 and 1.80 mm. Authors evaluate their experimental results by means of the most reliable binomial formula of the form:

$$\zeta = \frac{a}{R} + b \quad (R = \text{Reynolds' number})$$

For a layer of spheres, the formula

$$\zeta_0 = \frac{72.6}{R} + 0.9$$

is used, differing slightly in regard to the value of the free term from the formula suggested earlier by N. M. Zhavoronkov [N. M. Zhavoronkov, M. E. Aerov, and N. M. Umnik, *Zh. Fiz. Khim.* 23, no. 3, p. 342, 1949].

A table gives the value of the stratification coefficient for seven of the authors' experiments.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

## Porous Media

(See also Rev. 3478)

**3673. Scheidegger, A. E., Typical solutions of the differential equations of statistical theories of flow through porous media, *Trans. Amer. Geophys. Un.* 39, 5, 929-932, Oct. 1958.**

Paper deals with the solution of the differential equations for the statistical models of the effect of dispersion during the passage of a fluid through a porous medium. Two statistical models A and B are considered for two typical cases (progress of a slug and progress of a front). Model A corresponds to a random-walk picture of flow; model B assumes that there is autocorrelation between subsequent time-steps. The results are compared and the effect of the autocorrelation is shown. Graphs are given.

G. Sestini, Italy

**3674. Heinrich, G., and Desoyer, K., Practical method for the solution of problems of steady and unsteady underground flow (in German), *Ing.-Arch.* 26, 1, 30-42, 1958.**

Unconfined flow of groundwater is very difficult to analyze in practical problems because of the free surface which has the same properties as a free streamline in potential flow. Authors apply the relaxation method of Southwell to the problem and show how results can be readily obtained. Equations of motion are briefly derived and general properties and boundary conditions discussed. Transformation of variables is introduced to make relaxation method more readily applicable. Included is a co-ordinate change to eliminate effects of anisotropy of the media. Solutions of two typical problems are presented. The first is two-dimensional, unsteady flow through a trapezoidal-shaped dam. Typical unsteady free surface profiles show effects of drawdown on downstream face. Second solution is steady, axisymmetric flow to a well.

W. D. Baines, Canada

**3675. Kafarov, V. V., and Malinovskaya, T. A., Possibility of modelling a filtration process on the basis of analysis of the structure of the sediment (in Russian), *Khim. Prom-st'*, no. 8, 482-489, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 11806.**

The earlier published formulas, by different authors, for the determination of the resistance met with in the filtration of liquids through compressible sediments are examined. With the object of ascertaining the empirical principle of the resistance and for the purpose of computing the influence of changes of porosity on the speed (of filtration), tests were carried out with different types of suspensions. The measured values of the coefficients of resistance were recorded on a curve in relation to Reynolds numbers. Recommendations were put forward for modelling the filtration process.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3676. Poyarkova, K. D., Filtration of a liquid in heterogeneous twisted layers (in Russian), *Uch. Zap. Mosk. Obl. Ped. In-ta* 43, 35-45, 1956; Ref. Zh. Mekh. no. 10, 1957, Rev. 11784.**

The problem is examined of the laminar flow of a heterogeneous incompressible liquid into a gallery placed in a permeable layer of constant power, lying on an arbitrary surface. Between the contours of feed and discharge (of the gallery) the filtering layer consists of a finite number of homogeneous ring zones, on whose boundaries, and also on the contours of feed and discharge, the pressure, in transition from each zone to the neighbouring one, is considered to be constant and continuous. For the solution of the problem a system is selected of curvilinear, orthogonal coordinates ( $p, q$ ) in such a fashion, that the given boundary divisions of adjacent homogeneous zones, lying on the curvilinear surface, and also the contours of feed and discharge, should enter one of the families of coordinate lines (line  $p = \text{const}$ ). A formula is obtained for the determination of the discharge of the gallery; the relation found is analogous to the known relation of a gallery, placed in a plane homogeneous layer.

V. P. Pilatovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3677. Matveyenko, T. I., The problem of filtration through one and two strata (in Russian), *Trudi Odessk. In-ta, Ser. Matem. Nauk* 140, 6, 67-77, 1956; Ref. Zh. Mekh. no. 8, 1957, Rev. 9201.**

A solution is presented for the problem of the influx of water to a borehole in a pressureless stratum in consideration of the transfer from an adjacent stratum through an intermediate, poorly permeable layer. Since the starting equation is linearized by averaging over  $H(x, y)$ , the results obtained are the same as those of N. K.

Girinsky, A. N. Myat'yev, and P. Ya. Polubarinova-Kochina, who investigated the case of a pressure flow. Similar solutions have also been published elsewhere [C. E. Jacob, *Trans. Amer. Geophys. Un.* **27**, no. 11, 1946; M. S. Hantush and C. E. Jacob, *Trans. Amer. Geophys. Un.* **35**, no. 6, 1954].

Further, the influx to a borehole in a mass consisting of five strata (three highly permeable, two poorly permeable, the uppermost stratum forming a free surface) is analyzed. Differing from the preceding case, the pressure in any adjacent stratum is, in this instance, not assumed to be constant but to vary discontinuously by the effect of pumping. A similar scheme for a pressure flow has been investigated by N. K. Girinsky [In: "Methods of research and analysis in geological and hydrogeological engineering works," Gosgeolizdat, 1951].

In conclusion, author presents a solution for the plane (unidimensional) flow in a pressureless stratum, bounded underneath by a feebly-permeable stratum through which transfer takes place. This presents the known form of solution for the linearized equation as well as a new solution for the nonlinear case. Both solutions are correlated by means of numerical examples.

It is possible that a more accurate solution of the first two problems can be obtained by linearizing the starting differential equation, introducing the function  $u = H_1^2/2$ . It should be noted that for all three problems at  $r \rightarrow \infty$ , the conditions can be stated for  $H_2(\infty) \geq H_1(\infty)$  for which the author analyses the case  $H_2(\infty) = H_1(\infty)$ .

N. N. Verigin and F. M. Bochever  
Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3678. Vakhitov, G. G., and Govorova, G. L., Some radial problems of the displacement of petroleum by water from a stratum heterogeneous as regards permeability** (in Russian), *Trudi Vses. Neft'e-gaz. N.-i. In-ta* no. 8, 250-261, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11790.

The problem is examined of the radial displacement of petroleum by water from a stratum of constant power with two circular zones of different permeability. An evaluation is made of the difference in viscosity of the water and the petroleum and of the lowered phase permeability for the water in the zone of displacement of the petroleum by the water, which is assumed to be approximately constant. The liquid and the stratum are taken to be incompressible, and the filtration laminar. The case is also investigated of  $n$  circular concentric zones of varying permeability. The influence of heterogeneity on the time of contraction of the petroleum bearing contour towards the circular gallery is shown in an example.

V. L. Ladinov  
Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

**3679. Chueca, A., Water influx calculation and forecasting of pressure in an oil reservoir producing by water drive** (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liq.* **13**, 3, 222-245, Mar. 1958.

Author refers to the well-known method for future prediction of water-drive performance above a bubble point pressure in an oil reservoir. Determination of coefficients is obtained by a combination of the diffusivity equation with the material balance equation (as explained by Van Everdingen and Hurst). This first part of the paper is very clear, but the exposition is not very different from the usual explanations in this field (see, for instance, S. J. Pirson, "Oil reservoir engineering," second edition, McGraw-Hill Book Co. 1958).

The second part of the paper deals with an electrical analogy used in the same manner as suggested by Bruce [Trans. AIME 1943].

G. Supino, Italy

## Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 3199, 3435)

**3680. De Noyer, J., Determination of the energy in body and surface waves. Part I, Bull. Seism. Soc. Amer.** **48**, 4, 355-368, Oct. 1958.

Techniques for estimating the energy in seismic waves depend on analysis of ground motion at seismographic stations where the seismic disturbance has been recorded. The energy at the source that would be required to produce this ground motion at a distant station is then computed. Most such calculations have been restricted to Rayleigh waves which are surface waves propagating on the free surface of an elastic medium. The method followed is to consider the earth's surface to be represented by the free surface of a homogeneous, isotropic, semi-infinite medium.

Author presents an extension of the method for computing the energy in Rayleigh waves to consider the earth's surface to consist of a crustal layer overlying a semi-infinite medium of differing elastic properties. A method for computing the energy in Love waves propagating over the same crustal structure is presented. Limitations in proposed methods for computing the energy in longitudinal and transverse waves are considered. Numerical tables are presented for making estimates of initial energy from the ground motion at distant stations.

J. T. Wilson, USA

**3681. De Noyer, J., Determination of the energy in body and surface waves. Part II, Bull. Seism. Soc. Amer.** **49**, 1, 1-10, Jan. 1959.

Part II is an application of the methods presented in Part I (see preceding review). Consideration is given to measuring amplitudes and periods from seismograms and uncertainties caused by arrival of more than one phase of seismic waves during a given time interval. Numerical values for the energy in various phases of elastic waves are obtained for several intermediate to large shallow focus earthquakes. Author finds that there is no fixed relationship between the ratio of energy in one phase to the energy in another phase. In most examples studied the energy in transverse waves is large compared with the energy in other phases. Surface wave energy becomes larger for earthquakes that have been accompanied by surface faulting.

J. T. Wilson, USA

**Book—3682. Rules for arrangement of gaging stations [Richtlinien für den Bau von Pegeln]**, Koblenz, Bundesanstalt für Gewässerkunde, 1958, 55 pp.

This edition replaces previous preliminary rules (3rd edition, 1954). Following topics are explained: net of gaging stations, location for a gaging station; nonrecording gages, types, materials, recording gages, scales, accuracy; mechanical gage, float well, inlet, syphon, gage booth, protection against moisture, cold, aggressive water; pneumatic gages; electrical transmission of different systems. Data for planning transmissions. Stage indicators. These rules require a high standard of water-stage observations.

S. Kolupaila, USA

**3683. Lineikin, P. S., On the dynamics of steady currents in nonhomogeneous sea** (in Russian), *Doklady Akad. Nauk SSSR* (N. S.) **105**, 6, 1215-1217, Dec. 1955.

**3684. Lauwerier, H. A., Free motions in a rotating sea which has the form of a semi-infinite strip** (in English), *Math. Centrum Amsterdam, Rap.* **46**, 13 pp., June 1958.

**3685. Vorontsov, P. A., Vertical atmospheric pulsations as observed from an aircraft** (in Russian), *Trudi Gl. Geofiz. Observ.* no. 54, 44-58, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9174.

Values are given for the vertical velocity pulsations of the wind, observed above different subjacent surfaces. These characteristic data were obtained from the record of an accelerometer fitted in an aircraft. Material was used, obtained by expeditions of the A. I. Voyeykov Principal Geophysical Laboratory, in the Kamennaya Steppe, the region of Southern Kazakhstan, and in the Northwest of the European territory of the USSR, etc. The evaluation of the accelerograph record strips was made by the method suggested by A. S. Dubov [*Trudi Gl. Geofiz. Observ.* no. 16(78), 1949].

The mean and maximum values are given for the magnitude of the vertical wind pulsations above different subjacent surfaces, and the reproducibility of such values in height, for each region. Some relationships have been elucidated between the magnitude of the vertical pulsations and the state of the atmosphere. A table is given from which an indication can be obtained of the vertical wind pulsations by the intensity of pitching and ascending of a PO-2 aircraft, either from the values of the mean accelerometer loads, or the maximum overloads recorded on the instrument. From these accelerometer data, author calculates the values of the coefficient of the turbulent exchange.

K. G. Abramovich

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3686. Dogadkina, N. P., and Dyubyuk, A. F., Vertical velocities in the region of a stationary front** (in Russian), *Trudi Tsentralnaya Prognozov* no. 45 (72), 65-73, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9145.

The influence of friction in the region of the front is investigated, as well as the conditions in the atmospheric stratum near the ground at the surface of the front. The case of a steady front is investigated ( $du/dt = dv/dt = 0$ ) for which the solution of the following equation is sought:

$$\eta \frac{\partial^2 s}{\partial z^2} + i \eta s = \pi(z) \quad (\eta = \text{const})$$

$$\left( s = u + iv, \pi(z) = \frac{1}{\rho} \left[ \frac{\partial p}{\partial x} + i \frac{\partial p}{\partial y} \right] \right)$$

with the following boundary conditions: (1) At the ground, adhesion ( $s = 0$ ); at infinity, the velocity is limited.

Having written the solutions for  $u$  and  $v(s)$ , the derivatives  $\partial u/\partial x$  and  $\partial v/\partial y$  are calculated, and the vertical velocity  $w$  determined from the equation of continuity. From the resulting expressions, author endeavors to calculate the vertical velocities on either side of the surface of the front, at every 50 meters and in altitude at varying altitudes of the front, of 0, 500, 700, 1000 meters. It is noted that the ground stratum has a substantial influence on the vertical velocities in the region of the front for the case of low-level fronts.

V. P. Sadokov

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3687. Laykhtman, D. L., Determination of the total evaporation and heat loss from small water reservoirs** (in Russian), *Trudi Gl. Geofiz. Observ.* no. 53, 36-43, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9164.

The first part of the paper examines the problem of steady evaporation into moving, dry air, from a reservoir of rectangular shape, with consideration of the following factors: (1) Rate of transfer of the air masses above the reservoir; (2) Rate of vertical, turbulent exchange; (3) Rate of turbulent exchange in a direction perpendicular to the direction of motion.

The problem is reduced to solution of the following differential equation:

$$u(z) \frac{\partial q}{\partial x} = \frac{\partial}{\partial z} \left[ k_z(z) \frac{\partial q}{\partial z} \right] + k_y(z) \frac{\partial^2 q}{\partial y^2} + k_x(z) \frac{\partial^2 q}{\partial x^2}$$

with the following boundary conditions

$$q(x, y, z) = 0 \quad \text{for } z > 0, x = 0 \quad [1]$$

$$q = q_0 \quad \text{for } z = 0, x > 0, y > 0 \quad [2]$$

$$k_z \frac{\partial q}{\partial z} = 0 \quad \text{for } z = 0, x < 0, y < 0 \quad [3]$$

In addition it is assumed that  $q$  is restricted at infinity.

In the above,  $q$  is the density of the water vapor in  $g/m^3$  (absolute humidity),  $u(z)$  is the wind velocity,  $k_z, k_y, k_x$ , the coefficients of turbulent diffusion,  $q_0$  = temperature of the saturating water vapor at the temperature of the water surface.

The problem is solved by the methods of the theory of similarity.

The second part contains an analysis of the formula earlier derived by the author for the rate of evaporation or turbulent heat flow per unit surface [*Meteorol. i. Gidrobiologiya* 1947, no. 1].

Sh. A. Musaelyan

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3688. Sobanskaya, A. V., A method for determining the total reserve of thermal energy in an atmospheric air column by aerological data** (in Russian), *Sobshch. Akad. Nauk GruzSSR* 17, 7, 593-598, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9170.

The application of the energy of instability as an energy criterion of a particular atmospheric stratum is attended by a number of disadvantages, associated with the selection of the initial level or altitude, from which the rise of the atmospheric mass is to be investigated. Thus, the presence of a thin, inversion layer leads to an incorrect conclusion regarding the extent of the negative energy of instability in a layer of more considerable thickness. Consequently, it is suggested to substitute for the energy of instability (or parallel therewith), the heat content (enthalpy) of different layers of the atmosphere. It is demonstrated that it is in this case possible to disregard the heat content of the water vapors, compared with the heat content of the dry air. Then, the enthalpy in calories, for a particular layer between altitudes  $p_0$  and  $p$  (in millibars), will be expressed by the equation:

$$Q = 2.448 \int_{p_0}^p T dp \quad [1]$$

in which  $T$  is the absolute temperature. Calculation by Eq. [1] is easily performed by planimetry of the curve of  $T = T(p)$ , plotted from the data of aerological soundings. Instead of this, it is possible to approximate this curve by an intermittently-linear function

$$T_i = a_i p + b_i, p_{i-1} \leq p \leq p_i \quad (i = 1, \dots, n)$$

The total error in the calculation of  $Q$  by the formula in question amounts to 15-17%.

L. S. Gandin

*Courtesy Referativnyi Zhurnal, USSR*

*Translation, courtesy Ministry of Supply, England*

**3689. Broydo, A., Gorobey, V. N., Dyuzheva, O. G., Kalugina, M. A., and Pazgalova, E. A., Some singularities in the vertical distribution of the temperature in the lower part of the ground layer of the atmosphere** (in Russian), *Trudi Leningrad Gidrometeorol. In-ta* no. 5/6, 268-284, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9180.

The laws of temperature distribution in the lowest layer of the atmosphere nearest the ground—0.200 cm—are examined. The

temperature profile is characterized by means of a "curvature parameter" introduced by the authors, as follows:

$$b = \frac{t_0 - t_{100}}{t_0 - t_{200}}$$

This indicates which proportion of the total temperature variation in the layer from 0 to 200 cm falls to the share of the lowest part of the layer—from 0 to 50 cm. By means of the parameter  $b$ , authors endeavor to characterize the temperature profile of the ground layer from the data of station observations only (the criterion  $t_{200}$ ). In the summer time, the value of parameter  $b$  is highest during the day, perceptibly lower in the later evening and early morning, and increases at night somewhat, with reference to the late evening hours. A clearly defined relationship has been found between  $b/u_1$  (where  $u_1$  = wind velocity at 1 meter altitude) and the stability parameter  $\gamma = (t_0 - t_{200})/u_1^2$ .

A. Kh. Khrgian

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3690. Adem, J., On the relation between pressure and wind, with particular reference to a vortex, *Tellus* 10, 3, 326-330, Aug. 1958.**

When Eulerian hydrodynamical equations for nonviscous atmosphere are acted upon by curl and divergence operators, resulting derived equations are called, respectively, vorticity and "balance" equations. If flow is assumed two-dimensional and non-divergent, these equations are satisfied by a scalar stream function and a scalar potential; the latter is proportional to pressure. These functions relate pressure to wind. Paper points out that when equations are used for numerical forecasting in arbitrarily delineated regions the boundary conditions for the two functions are not independent; incorrect choice of pressure-wind relation on boundary will vitiate forecast.

Simple case of isolated vortex embedded in resting atmosphere is used for illustration. Result shows that when stream function vanishes on an outside boundary of vortex, pressure field is not constant outside region but is asymmetric due to variation of Coriolis parameter and contributes to resultant "body force" on vortex.

Reviewer believes analysis is sound though oversimplified, as is usual in meteorology. Main point of paper is one which should be borne in mind so long as arbitrary nonphysical boundaries must be used in numerical forecasting.

E. W. Barrett, USA

**3691. Thuronyi, G., compiled by, Recent literature on extended and long range forecasting, *Meteorol. Abstracts* 9, 7, 875-901, July 1958.**

The purpose of this compilation is to publish a group of unpublished abstracts on long-range forecasting which accumulated over the last few years because of printing limitations. It should be noted that the subjects of extended and long-range forecasting have been covered in two earlier bibliographies, those of January and February 1951 (MAB, Vol. 2, nos. 1 and 2). Additional items are listed in chronological order (of printing in MAB) and in the detailed subject outline. It is hoped that this compilation will serve the additional purpose of providing an index to some of the current world literature on extended and long-range forecasting.

From author's summary

## Naval Architecture and Marine Engineering

(See also Revs. 3538, 3539)

**3692. Lap, A. J. W., Some applications of the three-dimensional extrapolation of ship frictional resistance, *Intern. Shipbldg. Progr.* 5, 46, 249-268, June 1958.**

Author surveys methods of extrapolation for three-dimensional ship-form frictional resistance from model to prototype. It is shown that the two-dimensional method adopted by the International Towing Tank Conference at Madrid (I.T.T.C.-1957 method) can be applied as a basis for three-dimensional extrapolation. Important criteria governing three-dimensional methods are form factors which are functions of ship dimensions and draft, prismatic and volumetric coefficients. Due allowance can be made in the factors for scale effect in the resistance of appendages and for surface roughness. Additional factors governing resistance in restricted waters are water depth and water width. Author shows that frictional resistance is normally a larger part of total resistance than hitherto deduced from two-dimensional flat-plate data. Paper is accompanied by a comprehensive set of figures relating dimensionless parameters, and provides valuable design information.

B. W. Wilson, USA

**3693. Lap, A. J. W., and van Manen, J. D., Fundamentals of ship resistance and propulsion. Part A. Resistance; Part B. Propulsion (in English), *Netherlands Ship Model Basin Publ.* no. 129a, 124 pp.; no. 132a, 140 pp.**

A useful compilation of modern papers on both resistance and propulsion of ships, which might be characterized as a sound mixture of theory and practical experience. The first part on "Resistance" is written by A. J. W. Lap, the second one on "Propulsion" by J. D. van Manen. The chapters of the first part will certainly serve as a good guide for first information on all essential problems of ship resistance. The frictional resistance is treated in a particularly comprehensive manner.

The second part deals first with screw design on the basis of the well-known  $B - \delta$  diagrams for the Troost propeller series. The Gawn series are also discussed. The design on the basis of circulation theory is restricted to the free-running optimum propeller, and the wake-adapted propeller is treated on this basis as an approximation. The restriction entails that the theoretical considerations on contra-rotating propellers are not complete since for this problem methods are required which are beyond the scope of the paper. A chapter on nozzle propellers, paddle wheels and controllable pitch propellers as well as some remarks on trial and service prediction conclude the paper.

H. W. Lerbs, Germany

**3694. Havelock, T. H., The effect of speed of advance upon the damping of heave and pitch, *Quart. Trans. Instn. Nav. Arch.* 100, 2, 131-135, Apr. 1958.**

Aim of paper is to explore how damping coefficient of floating body varies with frequency of oscillation ( $p$ ) and speed of advance. Method is developed for line distribution of pulsating sources which author considers to approximate long narrow plant oscillating in pitch while advancing. Calculations support result derivable from theories of previous investigators (Haskind, Brard, Hanaoka) that damping coefficient becomes infinite when parameter  $pc/g = 1/4$  ( $c$  wave celerity,  $g$  acceleration of gravity). Findings are discussed with reference to recent experiments by Golovato which substantiate high damping coefficient in localized region near critical value of parameter.

M. St. Denis, USA

**3695. Watanabe, Y., and Inoue, S., On the property of rolling resistance of ship and its calculation, *Mem. Fac. Engrg. Kyushu Univ.* 17, 3, 117-128, Mar. 1958.**

## Friction, Lubrication and Wear

(See also Rev. 3365)

**3696. Panin, V. E., Influence of friction on the surfaces on the absorption of energy during friction (in Russian), *Fiz. Metallov i Metallovedenie* 3, 1, 172-178, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12224.**

Copper and aluminum test samples were subjected to compression with various ratios of  $d_0/b_0$  ( $b_0$  is the height,  $d_0$  is the diameter of the samples) and with various conditions of friction at the surfaces (reduction of friction was effected by introducing thin linings of Wood's metal). By means of the difference between the work of plastic deformation and the heat evolved, a determination was made of the latent energy of deformation. Increase of friction by reducing the  $d_0/b_0$  ratio or increase of the coefficient of friction at the surfaces leads to the increase of the stresses, the work of deformation and the latent energy of deformation with a simultaneous increase of the distortion of the lattice and the real hardening of the material.

V. M. Gol'dfarb

Courtesy Referativnyi Zhurnal, USSR  
Translation, courtesy Ministry of Supply, England

**3697. Savvin, A. P., Coplanar systems of friction forces** (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk*, no. 1, 144-149, Jan. 1957.

**3698. Bartenev, G. M., The frictional relations between highly elastic materials and hard smooth surfaces** (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **103**, 6, 1017-1020, Aug. 1955.

**3699. Scott, D., and Scott, H. M., The electron microscope in the study of wear**, Stockholm Conf. on Electron Microscopy Proc., 1956, 331-333.

**3700. Goepfert, G. J., and Williams, Josephine L., The wear of abrasives in grinding**, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-157, 5 pp.

**3701. Jonushas, R., Selection of the dimensions of a camshaft mechanism to ensure the minimum wear** (in Russian), *Trudi Fiz.-tehn. In-ta, Akad. Nauk LitSSSR*, **2**, 63-76, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11307.

A method is put forward for the calculation of the dimensions of a camshaft mechanism fitted with a flat rocking arm, to ensure the minimum wear of the cam surface. The starting point is the determination of the value of the work done by friction-sliding of the rocking arm along the profile, when the intenseness of wear, normal to the profile, is assumed to be proportional to the output of friction-sliding on the sliding track. If the rocking arm is working under tension, then the minimum value for wear and the maximum permissible value for the relation of the minimal radius of the cams to the inner center distance are obtained. In addition to the above the smallest clearances give the principle of constant acceleration. If the rocking shaft is working under compression then the smallest clearances and wear give the cosinusoidal principle of acceleration.

V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR  
Translation courtesy Ministry of Supply, England

**3702. Licht, L., Axial, relative motion of a circular step bearing**, ASLE-ASME Lub. Conf., Los Angeles, Calif., Oct. 1958. Pap. 58-LUB-1, 7 pp.

A mathematical analysis of the relation of axial motion of an externally pressurized thrust to lubricant flow has been made. Two fundamental equations are obtained which describe the axial motion and show the region of stability. It is shown that over the range of parameters studied small oscillations do not increase with time and that the bearing is stable regardless of the initial displacement, provided the fluid is incompressible. Analog computer solutions are given of both equations.

J. W. Givens, USA

**3703. Hirano, F., and Shodai, N., Oil-flow coefficient of pressure-fed journal bearing**, *Bull. JSME* **1**, 2, 184-188, June 1958.

The coefficient of forced feed flow has been calculated with the simplifying assumption that the oil film thickness is constant for a journal bearing.

R. Schnurmann, England

## Letters to the Editor

Re: AMR **11**, Rev. 3032 (August 1958): Kuske, A., Contributions to the evaluation of photoelastic experiments on disks and plates in transverse bending (in German), *Forsch. Geb. Ing.-Wes.* **23**, 1/2, 16-21, 1957.

In a letter to the editor, the author of the reviewed paper wishes to state that his paper deals with a new and complete theory of isocromatics, isoclinics, stress trajectories, isopachics, lines of constant shear stress and those of constant normal stresses in the vicinity of isotropic and also other points of biaxial stress systems. His new method of finding the isopachics by nomograms, referred to in my review as an "improvement of Neuber's method," is only a part of the results of the author's paper. Moreover, Dr. Kuske wishes to point out that his method avoids the usual source of inexactness caused by substituting differentials by differences.

E. Monch, Germany

**3705. Re: AMR 11**, Revs. 4629 and 4659 (November 1958): Source was given as *Acad. Repub. Pop. Romane, Rev. Mecan. Appl.* volume 2, number 2 instead of volume 2, number 1. The editors regret this error.

**3706. Re: AMR 12**, 506 (January 1959): Bartz, D. R., Factors which influence the suitability of liquid propellants as rocket motor regenerative coolants, *Jet Propulsion* **28**, 1, 46-53, Jan. 1958.

The summary following the above bibliographical heading pertains to another article [See AMR **10** (1957), Rev. 1926]. Correct author's summary is published in this issue (3624). The editors regret this error.

## Books Received for Review

BORG, S. F., and GENNARO, J. J., *Advanced structural analysis*, Princeton, New Jersey, D. Van Nostrand Co., Inc., 1959, xiii + 368 pp. \$7.50.

BOWDEN, F. P., and TABOR, D., *Reibung und Schmierung fester Korper*, Berlin, Springer-Verlag, 1959, xi + 430 pp. DM 41.40.

BRENNAN, J. N., editor, *Bibliography on shock and shock excited vibrations Vol. II*, University Park, Pa., Pennsylvania State University, 1957, x + 181 pp. \$2 (Paperbound).

CHEW, V., edited by, *Experimental designs in industry* (Symposium held N. C. State College Nov. 1956), New York, John Wiley & Sons, Inc., 1958, xi + 268 pp. \$6.

CUNNINGHAM, W. J., *Introduction to nonlinear analysis*, New York, McGraw-Hill Book Co., Inc., 1958, ix + 349 pp. \$9.50.

DJOUNKOVSKI, N. N., and BOJITCH, P. K., *La houle et son action sur les cotes et les ouvrages cotiers*, Paris, Editions Eyrolles, 1959, 404 pp. 5 837 F.

- FINNIE, I., and HELLER, W. R., Creep of engineering materials, New York, McGraw-Hill Book Co., Inc., 1959, ix + 341 pp. \$11.50.
- FOPPL, L., Elementare Mechanik, Munchen, R. Oldenbourg, 1959, 174 pp. DM 20.
- FRANCIS, J. R. D., and JACKSON, G., A textbook of fluid mechanics, New York, St. Martin's Press, Inc., 1958, viii + 332 pp. \$6.50.
- FRANK-KAMENETZKI, D. A., and PAWLOWSKI, J., Stoff-und Wärmeübertragung in der chemischen Kinetik, Berlin, Springer-Verlag, 1959, xv + 224 pp. DM 28.50.
- GELFOND, A. O., Differenzenrechnung, Berlin, VEB Deutscher Verlag der Wissenschaften, 1958, viii + 336 pp. DM 40.
- GRAVES, L. M., editor, Calculus of variations and its applications (Proceedings of Symposia in Applied Mathematics, Vol. VIII), New York, McGraw-Hill Book Co., Inc., 1959, v + 153 pp. \$7.50.
- GROBNER, W., and HOFREITER, N., Integraltafel; Unbestimmte Integrale, Wien, Springer-Verlag, 1957, viii + 166 pp. \$5.40.
- GROBNER, W., and HOFREITER, N., Integraltafel; Bestimmte Integrale, Wien, Springer-Verlag, 1958, vi + 204 pp. \$6.45.
- HANNAH, J., and STEPHENS, R. C., Mechanics of machines, New York, St. Martin's Press, Inc., 1958, viii + 238 pp. \$5.
- HOWARD, E. D., technical editor, Modern foundry practice, 3rd edition, New York, Philosophical Library, 1959, 464 pp. \$15.
- HARRIS, C. M. (edited by), Handbook of noise control, New York, McGraw-Hill Book Co., Inc., 1957, ix + 991 pp. + index. \$16.50.
- KOLLBRUNNER, C. F., and MEISTER, M., Ausbeulen Theorie und Berechnung von Blechen, Berlin, Springer-Verlag, 1958, xi + 344 pp. DM 42.
- KRESSER, W., Die Hochwasser der Donau, Wien, Springer-Verlag, 1957, 95 pp. \$2 (Paperbound).
- KRONER, E., Kontinuumstheorie der Versetzungen und Eigenspannungen, Berlin, Springer-Verlag, 1958, 179 pp. DM 17.10 (Paperbound).
- LANGHAAR, H. L., and BORESI, A. P., Engineering mechanics, statics and dynamics, New York, McGraw-Hill Book Co., Inc., 1959, xiv + 705 pp. + 2 indexes. \$9.
- LURJE, A. I., Einige nichtlineare Probleme aus der Theorie der selbsttragenden Regelung, Berlin, Akademie-Verlag, 1957, xi + 167 pp. DM 15.
- Material Properties Handbook, Vol. I; Aluminum Alloys, AGARD, 1958.
- MERRITT, F. S., Building construction handbook, New York, McGraw-Hill Book Co., Inc., 1958, xxxi + 859 pp. + index. \$15.
- MIHAILESCU, T., Geometrie diferenciala proiectiva, Bucuresti, Editura Academiei Republicii Populare Romine, 1958, 494 pp. Lei 25.90.
- MORICE, P. B., Linear structural analysis, New York, The Ronald Press Co., 1959, xii + 170 pp. \$6.
- NECHLEBA, M., Teorie indirektni regulace rychlosti, Praha, Statni nakladatelstvi technicke literatury, 1959, 383 pp. Kcs 38.
- NEWELL, F. B., Diaphragm characteristics, design and terminology, New York, American Society of Mechanical Engineers, 1958, v + 74 pp. \$3.75 (Paperbound).
- PEARSON, R. G., KLOOT, N. H., and BOYD, J. D., Timber engineering design handbook, New York, Cambridge University Press, 1959, 248 pp. \$6.
- PINNEY, E., Ordinary difference-differential equations, Berkeley, University of California Press, 1959, xii + 262 pp. \$5.
- PRIKEL, G., Tiefbohrtechnik, Wien, Springer-Verlag, 1959, xii + 414 pp. \$15.70.
- RITTER, R., Korrosionstabellen metallischer Werkstoffe geordnet nach angreifenden Stoffen, Wien, Springer-Verlag, 1958, 290 pp. \$11.65.
- SCHULZ, F., and FASOL, K. H., Wasserstrahlpumpen zur Förderung von Flüssigkeiten, Wien, Springer-Verlag, 1958, vi + 73 pp. \$3.55 (Paperbound).
- SMIRNOW, W. I., Lehrgang der höheren Mathematik, Teil IV, Berlin, VEB Deutscher Verlag der Wissenschaften, 1958, xii + 708 pp. DM 42.50.
- SPINK, L. K., Principles and practice of flow meter engineering, Foxboro, Mass., Foxboro Co., 1958, x + 549 pp. \$15.
- SZECHY, K., Alapozasi hibak, Budapest, Muszaki Konyvkiado, 1958, 116 pp. 49 - Ft.
- VOLTERRA, V., Theory of functionals and of integral and integro-differential equations, New York, Dover Publications, 1959, 226 pp. \$1.75 (Paperbound).
- WLASSOV, W. S., Allgemeine Schalen Theorie (German translation from the Russian), Berlin, Akademie-Verlag, 1958, xi + 661 pp. DM 75.

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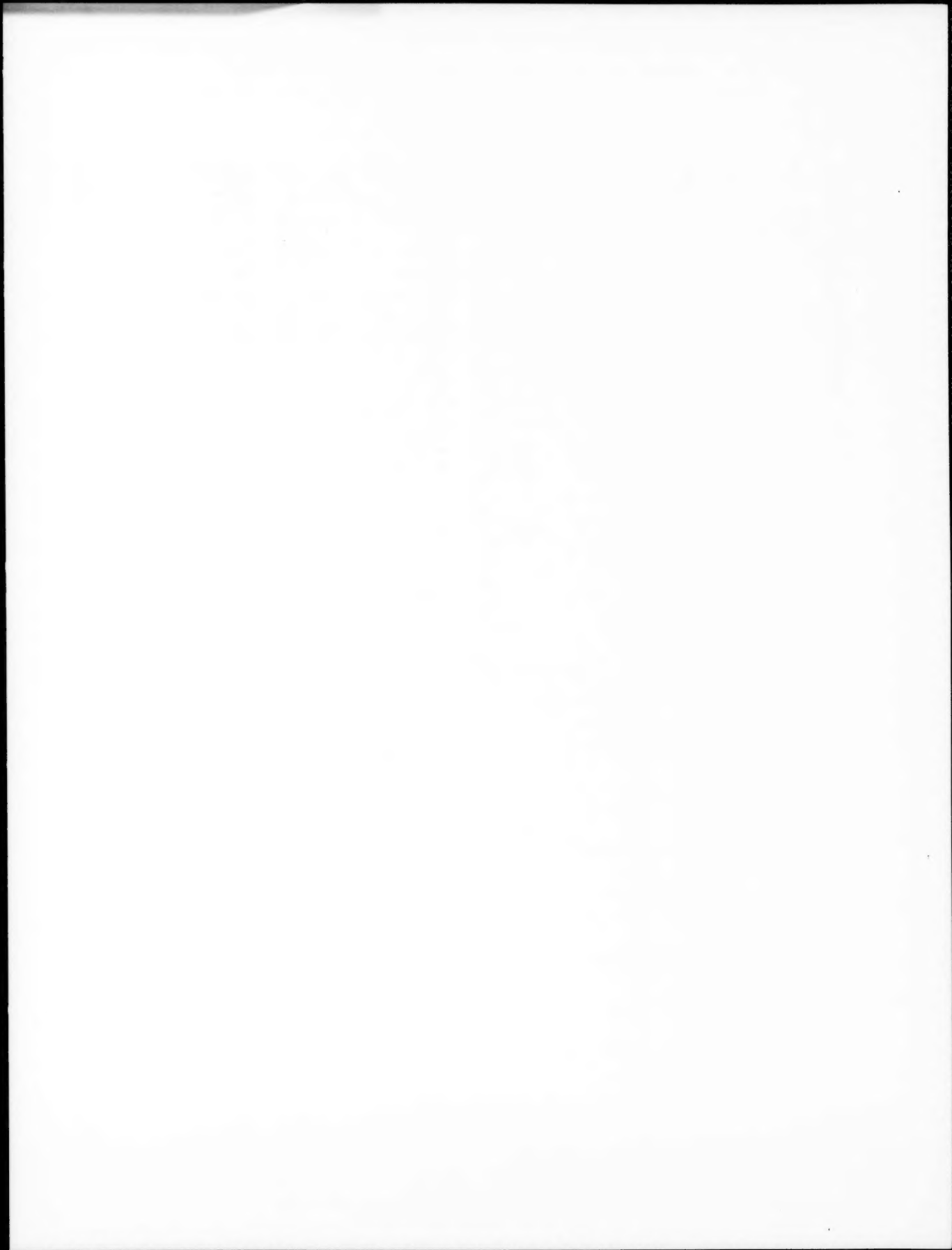
These test rules apply when the primary element is an orifice, a flow nozzle, or a Venturi tube. The fluid may be compressible or incompressible. The primary element may be installed within a continuous section of pipe flowing full, or at the inlet or exit of a plenum chamber. Specifically this Chapter includes information on the construction of these three primary elements, the recommended techniques governing tests, the necessary equations for computing rate of flow, examples to illustrate the application of typical data, a discussion of tolerances applicable to certain of the factors involved in the measurements, and an outline of the major advantages and disadvantages of various types of primary elements.

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